XT . R32

~~580.6~~
~~B77~~

PRO SCIENTIA SALUTE POPULIQUE

LIBRARY OF
THE NEW YORK BOTANICAL GARDEN
Income Jesup Fund
1921

Septemb 1899 R. W. Gibson Invt

377

The British Mycological Society

(*Recognosce notum, ignotum inspice*)

TRANSACTIONS

LIBRARY
NEW YORK
BOTANICAL
GARDEN

The British Mycological Society

(*Recognosce notum, ignotum inspice*)

TRANSACTIONS

Volume VII

Edited by

CARLETON REA and J. RAMSBOTTOM

CAMBRIDGE
AT THE UNIVERSITY PRESS
1922

Crypt
XT
.R32
v.7
1922

VOL. VII, PARTS I & II. *Published* 15 *July* 1921

The British Mycological Society

(*Recognosce notum, ignotum inspice*)

TRANSACTIONS 1920

Edited by

CARLETON REA and J. RAMSBOTTOM

Price to non-members, 12/6

CAMBRIDGE
AT THE UNIVERSITY PRESS
1921

LIST OF OFFICERS AND COUNCIL FOR 1921

Elected September 1920

President

CARLETON REA, B.C.L., M.A., Hon. memb. Brit. Myc. Socy, etc.

Vice-President

Miss GULIELMA LISTER, F.L.S., T. PETCH, B.A., B.Sc.

Treasurer and Foray Secretary

A. A. PEARSON, F.L.S.
59, Southwark Street, London, S.E. 1.

General Secretary

J. RAMSBOTTOM, M.A., F.L.S., O.B.E.
British Museum (Nat. Hist.), Cromwell Road, London, S.W. 7.

Secretary

Miss E. M. WAKEFIELD, F.L.S.
The Herbarium, Royal Botanical Gardens, Kew, Surrey.

Editors

CARLETON REA, B.C.L., M.A.
and
J. RAMSBOTTOM, M.A., F.L.S., O.B.E.

COUNCIL

The OFFICERS, with the following in addition:

W. B. ALLEN, Prof. R. H. BIFFEN, F. T. BROOKS, Prof. A. H. R. BULLER, Miss D. M. CAYLEY, A. D. COTTON, Very Rev. D. PAUL, T. PETCH, Prof. M. C. POTTER, Mrs E. A. REA, Miss A. LORRAIN SMITH, E. W. SWANTON, and H. WAGER.

SUB-COMMITTEE FOR PLANT PATHOLOGY

F. T. BROOKS, M.A. (*Chairman*)
E. J. BUTLER, C.I.E., D.Sc.
A. D. COTTON, F.L.S. (*Secretary*)
T. PETCH, B.A., B.Sc.
G. H. PETHYBRIDGE, B.Sc., Ph.D.
J. RAMSBOTTOM, M.A., F.L.S.

The President and Secretary of the Society *ex Officio*.

THE MINEHEAD FORAY.

September 27th to October 2nd, 1920.

The twenty-fourth annual meeting and autumn foray took place at Minehead, Somersetshire from September 27th to October 2nd, 1920. As usual most of the members assembled on the Monday and dispersed on the Saturday leaving four clear days for the business of the meeting proper.

A council meeting was held on Monday evening. Amongst other matters it was decided that a day's foray should be arranged for students of London colleges preceded by a semi-popular lecture*; and further, to attempt in some way to clear up the confusion in mycology, due to the many descriptions of new genera which have appeared since the publication of the last volume of Saccardo's Sylloge Fungorum, by reprinting the original diagnoses and to keep up to date by annual lists.

The first excursion was a whole day one to Horner Woods. All of the woods visited are of the same type namely typical *Quercus sessiliflora* woods on Devonian sandstone and marl. The journeys on the first three days were made by motor charabanc. The detailed knowledge of the district possessed by Mr Norman G. Hadden enabled him to suggest the splitting of the party where desirable either from the point of view of individual collecting or of personal comfort. At the starting point *Coprinus flocculosus* was discovered inside an old elm. *Lasiobolus macrotrichus* and *Ascophanus cervarius* were found in quantity, both on red deer dung: Horner Woods is the type locality for the former; the colour of the latter is whitish or pallid when fresh and does not become the "chestnut brown" colour of the original description until it is old†. Other interesting fungi were *Chlorosplenium versiforme, Podosphaera myrtillina, Thecopsora Vacciniorum, Hygrophorus subradiatus* var. *lacmus, Coprinus picaceus, Clavaria luteoalba, Cyphella alboviolascens* and *Merulius tremellosus*. The president was successful in finding *Myriangium Duriaei* on *Chionaspis salicis* on Ash.

In the evening the general meeting was held. Mr Carleton Rea was elected President for 1921, Miss G. Lister and Mr T. Petch, Vice-Presidents, Mr J. Ramsbottom, General Secretary and Miss D. Cayley and Mr F. T. Brooks as members of the Council —the other officers being re-elected.

* The lecture was given on October 22, 1920 at University College, London (at the invitation of Prof. F. W. Oliver) by Mr Somerville Hastings who showed slides of and described the larger fungi likely to be found the following day on the foray at Oxshott.

† See p. 59.

The Treasurer's statement showed the necessity for the increase in the annual subscription from 10*s.* to £1, due notice of which had been given to members. The discussion which followed showed that many present were of the opinion that an even greater increase was advisable, but it was suggested that it would doubtless be more beneficial to the Society if the necessary funds were obtained by increased membership.

The invitation from the Haslemere Natural History Society to hold the Spring Foray at Haslemere at Whitsun, and that from the Worcestershire Naturalists Club to hold the autumn foray at Worcester* were accepted.

Mr W. N. Cheesman was appointed delegate of the Society to the British Association meeting at Edinburgh.

The President paid tribute to the memory and work of Monsieur E. Boudier and Signor P. A. Saccardo who were highly esteemed honorary members of the Society. He proposed that Monsieur N. Patouillard and Professor R. Thaxter be elected honorary members.

It was decided that fraternal greetings be sent to the Société Mycologique de France†, and to couple with them expressions of sympathy on the death of M. Boudier.

On Wednesday a start was made at noon, the mornings being devoted as usual during the rest of the foray to an examination of the previous day's finds. The woods at Selworthy were visited. Just before turning into the woods a number of specimens of *Clavaria stricta* were found in the hedge bottom and a mass of *Hirneola Auricula-Judae* on *Berberis arcuata*. This proved to be the best day of the foray for collecting Basidiomycetes but the district had not had sufficient rain from a mycological point of view. Interesting additions to the list were *Lepiota excoriata, Tricholoma columbetta, Russula incarnata, Poria sanguinolenta, Femsjonia luteoalba* and *Septoria thecicola.*

In the evening Mr T. Petch gave his Presidential Address on "Fungi parasitic on scale insects‡."

Porlock woods were visited on Thursday. The most interesting addition was a patch of about 30 specimens of *Geaster fimbriatus*. Owing to the day being wet certain members of

* Sept. 19–24, 1921.

† The following reply was received from M. A. Maublanc, General Secretary of the Société Mycologique de France. "Les membres de la Société Mycologique de France, réunis en séance le 4 Novembre, après avoir pris connaissance de la lettre que vous avez adressée à M. Moreau, me prient de bien vouloir être leur interprète pour adresser à la Société Mycologique anglaise leurs chaleureux remerciements pour le fraternel salut et les vœux qu'elle leur adresse.

Très touchés de la marque de sympathie de leurs confrères d'Angleterre, ils formulent leurs souhaits les plus sincères pour la prospérité de votre Société."

‡ See p. 18.

the party found it more advantageous to devote their attention to microfungi. The district is extremely rich in rust fungi (see Hadden in Journ. Bot. 1920, p. 37) and many of these were found including *Puccinia Moliniae, P. Absinthii, Milesina Dietcliana, M. Blechni* and *Uredo Scolopendrii. Pachyella depressa, Androsaceus Hudsonii, Paxillus panuoides, Hypochnus granulosus* (Peck) Burt* and a lavender form of *H rosco-griseus* Wakef. and Pears† were also listed.

Mr Carleton Rea opened the proceedings in the evening with a paper on the genus *Ganoderma* (Karst.) Pat. This genus is characterised by its shining, resinous, laccate crust and coloured, smooth or rough, oval spores which are truncate at the base. The species may be sessile or stipitate, and in this country include *G. lucidum* (Leyss.) Karst., *G. applanatum* (Pers.) Pat. and var. *laccatum* (Kalchbr.) with verrucose spores and *G. australe* (Fr.) Pat. with its var. *vegetum* (Fr.) Romell, and *G. resinaceum* Boud. with smooth spores.

Mr Rea also exhibited a painting by Miss V. Rea of *Phallus imperialis* and showed some "eggs" which had been collected at Blakeney, Norfolk by Professor F. W. Oliver.

Another interesting phalloid sent for exhibition was *Clathrus cancellatus* collected in the Isle of Wight by Mr W. Johnson.

Mr J. Ramsbottom then gave an account of mycorhiza in orchids. A seed of such an orchid as Odontoglossum is undifferentiated except that the cells at the suspensor end are much the larger. If the seed be sown it merely swells: as Bernard showed, however, the seeds germinate readily if sown on a culture of the fungus extracted from the root of the orchid. The fungus passes through the suspensor into the large cells. Rapid division then takes place in the small cells at the antipodal end of the seed. Here the growing point of the stem is laid down and later the growing point of the root. The young root absorbs its way through the tissues of the "protocorm" and emerges at the side without touching the fungus zone, thus being free from hyphae on entering the soil. It has usually reached a length of ·5 cm. before it becomes infected from the soil. Flasks showing Odontoglossum seedlings grown on a commercial scale, a culture of the "fertilising" fungus and a series of microtome sections prepared by the late Mr J. Charlesworth were exhibited.

The President gave a short account of a paper on Indian Polyporaceae by Professor S. R. Bose.

Mr Ramsbottom then exhibited a "yeast" *Medusomyces Givesii* cultivated in tea, and also the Ginger Beer Plant ‡.

On Friday morning the party made the short journey to

* See p. 57. † See p. 57. ‡ See p. 86.

Dunster by train. There were few of the larger fungi to be seen, but *Lepiota nympharum, L. haematosperma, L. Friesii* and *Pleurotus corticatus* were met with. *Kuehneola albida* was not uncommon and *Oidium alphitoides* on Beech and *Helotium moniliferum* were collected. Most members walked back to Minehead along the coast.

At the evening meeting a communication was read from Professor A. H. R. Buller on the audibility of the "puffing" in the larger Discomycetes. A specimen of *Pustularia catinus* was seen to puff and was held to the ear as one does a shell: a distinct sound was heard like that made by steam when escaping from a tiny jet.

A note by Mr St John Marriott on the discharge of the peridiolum in *Sphaerobolus stellatus* stated that the greatest distance to which these had been thrown was twelve inches.

Mr R. Paulson then gave a paper on "The sporulating gonidia of *Evernia prunastri**."

Mr Ramsbottom exhibited pieces of canvas from different war areas showing "diamond spot" caused by *Macrosporium* and *Stemphylium* which was responsible for so much damage to tentage and which is of great economic importance. The methods of treatment which had been advocated to prevent the trouble were briefly commented on and specimens of treated canvas exhibited.

The meeting ended by votes of thanks to Captain Luttrell for permission to explore Dunster and to Mr N. G. Hadden for making the arrangements for the excursions; to the Foray Secretary, Mr A. A. Pearson, and to the President Mr T. Petch.

All the members present contributed in some way or other in the compilation of the following list of species found during the foray. I would express my thanks particularly to Mr Carleton Rea for assistance in the field and to Dr J. S. Bayliss Elliott, Mr C. H. Grinling, Mr N. G. Hadden, Sir H. Hawley and Mr A. A. Pearson for lists of their finds.

M = Neighbourhood of Minehead. *H* = Horner Woods. *S* = Selworthy. *P* = Porlock. *D* = Dunster.

HYMENOMYCETES.

Amanita phalloides (Vaill.) Fr. *D.*, mappa (Batsch) Fr. *P.D.*, muscaria (L.) Fr. *S.P.*, rubescens Fr. *H.S.*

Amanitopsis vaginata (Bull.) Roze *D.*, fulva (Schaeff.) W. G. Sm. *S.P.*

Lepiota procera (Scop.) Fr. *D.*, excoriata (Schaeff.) Fr. *S.*, Friesii (Lasch) Fr. *D.*, cristata (A. and S.) Fr. *P.D.*, nympharum Kalchbr. *D.*, granulosa (Batsch) Fr. *H.*, amianthina (Scop.) Fr. *H.S.*, sistrata Fr. *P.*, haematosperma (Bull.) Boud. *D.*

Armillaria mellea (Vahl.) Fr. *H.D.*

Tricholoma resplendens Fr. *S.*, flavobrunneum Fr. *H.*, albobrunneum (Pers.) Fr. *H.S.*, rutilans (Schaeff.) Fr. *H.S.*, columbetta Fr. *S.*, terreum (Schaeff.)

* See p. 41.

Fr. *S.*, sulphureum (Bull.) Fr. *S.*, nudum (Bull.) Fr. *D.*, sordidum *D.*, melaleucum (Pers.) Fr. *D.*, grammopodium (Bull.) Fr. *H.*

Clitocybe nebularis (Batsch) Fr. *H.D.S.*, clavipes (Pers.) Fr. *H.S.*, infundibuliformis (Schaeff.) Fr. *S.*, flaccida (Sow.) Fr. *S.*

Laccaria laccata (Scop.) B. and Br. *H.S.P.D.* var. amethystina (Vaill.) B. and Br. *H.S.P.D.*

Collybia maculata (A. and S.) Fr. *H.*, distorta Fr. *H.*, butyracea (Bull.) Fr. *S.*, confluens (Pers.) Fr. *S.*, fusipes (Bull.) Berk. *S.*, radicata (Rehl.) Berk. *P.*, dryophila (Bull.) Fr. *H.S.*

Mycena pelianthina Fr. *P.*, Iris Berk. *H.*, pura (Pers.) Fr. *S.D.*, rugosa Fr. *H.D.*, galericulata (Scop.) Fr. *H.*, polygramma (Bull.) Fr. *S.*, alcalina Fr. *S.*, ammoniaca Fr. *H.*, metata Fr. *S.P.D.*, amicta Fr. *H.*, virens (Bull.) Quél. *S.*, haematopus (Pers.) Fr. *S.H.P.*, galopus (Pers.) Fr. var. nigra Fl. Dan. (Syn. leucogala Cke.) *H.D. S.*, inclinata Fr. *D.*, epipterygia (Scop.) Fr. *D.*, rorida Fr. *P.*, corticola (Schum.) Fr. *S.*

Omphalia grisea Fr. *P.*, fibula (Bull.) Fr. *H.*, var. Swartzii Fr. *P.*

Pleurotus corticatus Fr. *D.*, petaloides (Bull.) Fr. *P.*, subpalmatus Fr. *H.*

Hygrophorus pratensis (Pers.) Fr. *H.S.*, virgineus (Wulf.) Fr. *H.*, subradiatus (Schum.) Fr. var. lacmus Fr. *H.*, laetus (Pers.) Fr. *H.*, puniceus Fr. *H.*, chlorophanus Fr. *H.*, coccineus (Schaeff.) Fr. *H.*, psittacinus (Schaeff.) Fr. *S.*

Lactarius torminosus (Schaeff.) Fr. *S.D.*, turpis (Weinm.) Fr. *S.*, deliciosus (L.) Fr. *S.*, quietus Fr. *S.P.*, rufus Fr. *H.*, glyciosmus Fr. *S.*, subdulcis (Bull.) Fr. *H.S.*

Russula nigricans (Bull.) Fr. *S.D.*, furcata (Pers.) Fr. *S.*, rosacea (Pers.) Fr. *S.*, drimeia Cke. *H.S.M.*, incarnata Quél. *S.*, virescens (Schaeff.) Fr. *S.P.*, atropurpurea (Krombh.) Maire *S.*, lepida Fr. *P.*, vesca Fr. *S.*, cyanoxantha (Schaeff.) Fr. *H.S.*, heterophylla Fr. *S.*, consobrina Fr. *S.*, fellea Fr. *H.S.*, emetica (Schaeff.) Fr. *S.*, ochroleuca (Pers.) Fr. *S.P.*, fragilis (Pers.) Fr. *H.S.*

Cantharellus cibarius Fr. *H.S.P.*

Marasmius oreades (Bolt.) Fr. *M.*

Androsaceus androsaceus (L.) Pat. *H.D.* rotula (Scop.) Pat. *D.*, Hudsonii (Pers.) Pat. *P.D.*

Panus torulosus (Pers.) Fr. *D.*, stypticus (Bull.) Fr. *P.*

Lenzites betulina (L.) Fr. *H.P.*

Pluteus cervinus (Schaeff.) Fr. *S.D.*

Entoloma jubatum Fr. *S.*, costatum Fr. *P.*, sericeum (Bull.) Fr. *H.D.*

Clitopilus prunulus (Scop.) Fr. *S.*

Leptonia lampropus Fr. *H.S.*, chloropolia Fr. *H.*, sericella (Fr.) Quél. *H.*

Nolanea pascua (Pers.) Fr. *H.*, proletaria Fr. *H.S.*, mammosa (L.) Fr. *P.*

Pholiota squarrosa (Mull.) Fr. *H.S.P.*

Inocybe rimosa (Bull.) Fr. *H.D.*, asterospora Quél. *S.D.*, eutheles B. and Br. *D.*, geophylla (Sow.) Fr. *H.P.D.*, maritima Fr. *H.*

Hebeloma fastibile Fr. *S.*, mesophaeum Fr. *P.*

Flammula carbonaria Fr. *H.*, sapinea Fr. *D.*

Naucoria escharoides Fr. *H.*

Galera tenera (Schaeff.) Fr. *S.*, hypnorum (Schrank) Fr. *H.M.*

Tubaria furfuracea (Pers.) W. G. Sm. *H.D.*

Cortinarius (Phlegmacium) triumphans Fr. *S.*, balteatus Fr. *H.*, varius (Schaeff.) Fr. *H.P.*,
(Myxacium) elatior Fr. *H.S.*, alboviolaceus (Pers.) Fr. *S.*,
(Dermocybe) tabularis (Bull.) Fr. *S.*, anomalus Fr. *S.*, miltinus Fr. *S.*, sanguineus (Wulf.) Fr. *H.P.*, cinnamomeus (L.) Fr. *H.P.* var. semisanguineus Fr. *H.*,
(Telamonia) hinnuleus (Sow.) Fr. *H.*, hemitrichus (Pers.) Fr. *H.*, rigidus (Scop.) Fr. *H.S.*, paleaceus (Weinm.) Fr. *H.*,
(Hydrocybe) leucopus (Pers.) Fr. *H.M.*, acutus (Pers.) *S.*

Paxillus involutus (Batsch) Fr. *H.S.*, panuoides Fr. *P.*

Psaliota arvensis (Schaeff.) Fr. *M.*, campestris (L.) Fr. *S.*, var. silvicola (Vitt.) Fr. *S.*

Stropharia aeruginosa (Curt.) Fr. *S.P.*, semiglobata (Batsch) Fr. *H.M.*, squamosa Fr. *H.*, merdaria Fr. *H.*, coronilla (Bull.) Fr. *D.*

Hypholoma capnoides Fr. *H.*, epixanthum (Paul.) Fr. *H.*, fasciculare (Huds.) Fr. *H.S.P.*, pyrotrichum (Holmsk.) Fr. *H.*, velutinum (Pers.) Fr. *P.*, appendiculatum (Bull.) Fr. *S.D.*, hydrophilum (Bull.) Fr. *H.P.*
Psilocybe semilanceata Fr. *H.M.*, foenisecii (Pers.) Fr. *S.*
Coprinus comatus Fl. Dan. *S.*, atramentarius (Bull.) Fr. *H.*, picaceus (Bull.) Fr. *H.*, flocculosus (DC.) Fr. *H.*, micaceus (Bull.) Fr. *S.*, radiatus (Bolt.) Pers. *M.*, plicatilis (Curt.) Fr. *S.*
Panaeolus campanulatus (L.) Fr. *H.*, papilionaceus (Bull.) Fr. *S.*
Anellaria separata (L.) Karst. *H.D.*
Psathyrella gracilis (Pers.) Fr. *S.D.*, atomata Fr. *S.*
Boletus luteus (L.) Fr. *H.P.*, elegans (Schum.) Fr. *H.S.P.*, granulatus (L.) Fr. *D.*, bovinus (L.) Fr. *H.*, badius Fr. *S.P.*, piperatus (Bull.) Fr. *S.*, variegatus (Swartz) Fr. *H.*, chrysenteron (Bull.) Fr. *H.S.D.*, subtomentosus (L.) Fr. *H.S.*, parasiticus (Bull.) Fr. *D.*, edulis (Bull.) Fr. *S.*, luridus (Schaeff.) Fr. *H.S.*, scaber (Bull.) Fr. *H.S.P.*
Fistulina hepatica (Huds.) Fr. *S.P.D.*
Polyporus squamosus (Huds.) Fr. *H.*, f. erecta Bres. *D.*, elegans (Bull.) Fr. var. nummularius Fr. *S.*, caesius (Schrad.) Fr. *S.P.*, rutilans (Pers.) Fr. *H.S.*, adustus (Willd.) Fr. *H.*, hispidus (Bull.) Fr. *S.*, dryadeus (Pers.) Fr. *S.*, betulinus (Bull.) Fr. *S.*
Fomes ulmarius (Sow.) Fr. *S.D.*, annosus Fr. *D.*, fomentarius (L.) Fr. *S.*, pomaceus (Pers.) Fr. *M.*
Ganoderma applanatum (Pers.) Pat.
Polystictus versicolor (L.) Fr. *H.S.P.D.*, radiatus (Sw.) Fr. *H.S.D.*, hirsutus (Schrad.) Fr. *H.S.P.*, zonatus (Nees.) Fr. *S.*, abietinus (Dicks.) Fr. *H.*
Poria terrestris (DC.) Fr. *H.*, sanguinolenta Fr. *S.D.*
Daedalea quercina (L.) Fr. *D.*
Merulius tremellosus (Schrad.) Fr. *H.*, corium (Pers.) Fr. *H.*, rufus (Pers.) Fr.
Hydnum repandum (L.) Fr. *P.*, auriscalpium (L.) Fr. *H.*
Irpex obliquus (Schrad.) Fr. *H.S.P.D.*
Radulum orbiculare Fr. *S.*
Phlebia merismoides Fr. *H.S.*
Grandinia granulosa Fr. *H.*, Brinkmanni Bres. (Corticioid form).
Odontia fimbriata (Pers.) Fr. *H.*, farinacea (Pers.) Quél. *H.*, bicolor (A. and S.) Bres. *H.*
Thelephora terrestris Ehrb. *S. H.*
Stereum hirsutum (Willd.) Fr. *H.S.D.*, sanguinolentum (A. and S.) Fr. *P.*, rugosum (Pers.) Fr. *H.S.D.*
Hymenochaete rubiginosa (Dicks.) Lév. *S.*, cinnamonea (Pers.) Bres. *P.*
Corticium lacteum Fr. *H.*, laeve (Pers.) Fr. *S.*, Sambuci (Pers.) Fr. *S.*, porosum Berk., praetermissum (Karst.) Bres. *P.*, albostramineum (Bres.) Wakef. *P.*, lactescens Berk. *H.*, lividum (Pers.) Fr.
Peniophora quercina (Pers.) Cke. *H.S.*, cinerea (Fr.) Cke. *S.*, velutina (DC.) Cke. *H.*, incarnata (Pers.) Cke., hydnoides Cke. and Mass., pubera (Fr.) Sacc.
Coniophora arida Fr. *P.*
Hypochnus isabellinus Fr. *H S.*, fuscus (Pers.) Karst., ferrugineus (Pers.) Fr., roseo-griseus Wakef. and Pears. var. lavendulaceus Pears. *P.*, granulosus (Peck) Burt *P.*
Exobasidium Vaccinii Woron. *H.P.*
Cyphella alboviolascens Karst. *H.P.*, capula (Holmsk.) Fr. *H.*
Clavaria cinerea (Bull.) Fr. *S.D.*, rugosa (Bull.) Fr. *H.S.D.*, stricta (Pers.) Fr. *S.*, fusiformis (Sow.) Fr. *S.P.D.*, luteoalba Rea *H.*, dissipabilis Britz. *H.*
Pistillaria micans (Pers.) Fr. *P.*, quisquiliaris Fr. *H.P.*, puberula Berk. *H.*
Hirneola Auricula-Judae (L.) Fr. on *Berberis arcuata S.*, on *Ilex D.*
Exidia glandulosa (Bull.) Fr. *D.*
Tremella mesenterica (Retz.) Fr. on *Ulex H.D.*
Femsjonia luteoalba Fr. *S.*
Dacryomyces deliquescens (Bull.) Duby *H.*
Calocera cornea (Batsch) Fr. *H.P.*
Phallus impudicus (L.) Pers. *H.*
Mutinus caninus (Huds.) Fr. *D.*
Cyathus striatus Hoffm. *S.*

Nidularia pisiformis Tul. *H.*
Geaster fimbriatus Fr. *P.*
Bovista plumbea Pers. *H.*, nigrescens Pers. *H.S.*
Lycoperdon perlatum Pers. *S.*, depressum Bon. *M.P.*, pyriforme (Schaeff.) Pers. *D.*
Scleroderma vulgare Horn. *H.S.D.*, verrucosum (Vaill.) Pers. *S.P.D.*

UREDINEAE.

Uromyces sparsus (K. et Sch.) Lév. on *Spergularia salina, P. Marsh*, Loti Blytt *M.*, striatus Schroet. on *Trifolium minus P.*, Trifolii (Hedw.) Lév. *P.*, flectens Lagerh. *M.*, Fabae (Pers.) de By. on Broad bean *M.S.*, on *Vicia sepium P.*, Valerianae (Schum.) Fuck. on *V. sambucifolia P.*, Salicorniae (DC.) de By. *P. Marsh*, Polygoni (Pers.) Fuck. *S.*, Rumicis (Schum.) Wint. *H.S.P.*, Dactylidis Oud. *H.S.P.*
Puccinia Violae (Schum.) DC. *H.S.P.D.*, Lychnidearum Link, *H.P.*, Malvacearum Mont. *M.D.*, pulverulenta Grev. *H.*, Circaeae Pers. *H.S.P.D.*, Aethusae Mart. *P.*, Absinthii DC. *P.*, on *Artemesia Absinthium*, obtegens (Link) Tul. *S.D.*, expansa Link. *P.*, Cirsii Lasch. *M.S.*, Hieracii (Schum.) Mart. *P.D.*, Hypochoeridis Oud. *D.*, Lapsanae (Schultz.) Fuck. *P.*, Taraxaci Plowr. *D.*, Primulae (DC.) Duby *H.S.P.D.*, Glechomatis DC. *H.*, Menthae Pers. on *Calamintha clinopodium H.*, and *Mentha aquatica P.*, annularis (Str.) Schlecht. *P.*, Acetosae (Schum.) Koern. *H.*, Iridis (DC.) Wallr. on *Iris foetidissima P.D.*, oblongata (Link.) Wint. *P.*, Caricis (Schum.) Rebent. *H.*, graminis Pers. *H.S.P.D.*, glumarum (Schm.) Erikss. and Henn. *P.*, dispersa Erikss. and Henn. *P.*, Baryi (B. and Br.) Wint. *H.S.P.*, Phragmitis (Schum.) Koern. *H.P.D.*, Poarum (Niels.) Wint. *P.*
Phragmidium subcorticium (Schrank) Wint. *P.*, violaceum (Schultz.) Wint. *H.S.P.D.*
Kuehneola (Phragmidium) albida (Kuehn.) Magn. *D.*
Coleosporium Euphrasiae (Schum.) Wint. *P.*, Melampyri (Rebent.) Kleb. *P.*, Senecionis (Pers.) Fr. *H.S.P.D.*, Sonchi-arvensis (Pers.) Lév. *P.*, Tussilaginis (Pers.) Kleb. *H.S.P.D.*
Pucciniastrum Circaeae (Schum.) Schroet. *D.*, Agrimoniae (DC.) Tranzsch. *P.*
Melampsora Hypericorum (DC.) Schroet. on *Hypericum Androsaemum*, Laricicaprearum (Link) Karst. *H.S.P.*
Melampsoridium betulinum (Pers.) Kleb. *H.S.P.D.*
Thecopsora (Pucciniastrum) Vacciniorum (Link) Karst. *H.P.*, Dieteliana (Syd.) Magn. on *Polypodium vulgare D.*
Milesina (Melampsorella) Blechni (Syd.) Magn. *D.*
Uredo Scolopendri (Schroet.) *P.D.*

USTILAGINEAE.

Spacelotheca Hydropiperis (Schum.) de By. *H.P.*

PYRENOMYCETES.

Sphaerotheca pannosa (Wallr.) Lév. *M.*, Castagnei Lév. *S.P.*
Podosphaera oxyacantha (DC.) de By. *H.*, myrtillina (Schub.) Kunze. *H.P.*, leucotricha Salm. *H.*
Uncinula Aceris (DC.) Sacc. *H.S.P.D.*
Microsphaera Grossulariae (Wallr.) Lév. *D.*, mougeotii Lév. on *Lycium M.D.*
Phyllactinea suffulta (Rebent.) Sacc. *P.*
Erysiphe Cichoracearum DC. *H.P.*, graminis DC. *D.*, Polygoni DC. *H.D.*
Eurotium herbariorum (Wigg.) Link *P.*,
Nectria cinnabarina (Tode) Fr. *S.P.*, Peziza (Tode) Fr. *D.*
Hypomyces rosellus (A. and S.) Tul. *H.*, aurantius (Pers.) Tul. *H.*
Hypocrea rufa (Pers.) Fr. *H.*, fungicola Karst. *S.*
Claviceps purpurea (Fr.) Tul. *S.P.D.*, microcephala (Wallr.) Wint. *H.P.*
Cordyceps militaris (L.) Link *S.*, ophioglossoides (Ehrb.) Link *H.P.*
Chaetomium elatum Kunze. *P.*
Sordaria macrospora Auersw. *H.*, fimicola (Rob.) Ces. and de Not. *H.*, discospora (Auersw.) Niessl. var. major Wint. *H.*, maxima Niessl. *H.*

Podospora coprophila (Fr.) Ces. and de Not. *D.*
Delitschia minuta Fuck. *H.*
Sporormia ambigua Niessl. *H.*
Trichosphaeria pilosa (Pers.) Fuck. *S.*
Herpotrichia Pinetorum (Fuck.) Wint. *H.* on *Ulex.*
Leptospora ovina (Pers.) Fuck. *D.*
Chaetosphaeria phaeostroma (Dur. and Mont.) Wint. *S.*
Rosellinia mammiformis (Pers.) Wint. *S.*
Melanomma Pulvis-pyrius (Pers.) Fuck. *H.*, fuscidulum Sacc. *P.* on *Sambucus*
Zignoëlla ovoidea (Fr.) Sacc. *H.*, ostioloidea (Cke.) *P.*
Ceratostomella cirrhosa (Pers.) Sacc. *H.*
Stigmatea Robertiani Fr. *P.*
Sphaerella punctiformis Sacc. *H.P.*
Venturia Rumicis (Desm.) Wint. *P.*, maculaeformis (Desm.) Wint. *H.*
Pleospora herbarum (Pers.) Rabh. *P.*
Anthostomella appendiculosa (B. and Br.) Sacc. *S.* on *Fraxinus.*
Diaporthe crustosa Sacc. and Roum. *H.*, decorticans (Lib.) Sacc. and Roum. *D.* on *Prunus cerasus.*
Valsa Eutypa (Achar.) Nits. *M.H.* on *Fraxinus.*
Melanconis stilbostoma (Fr.) Tul. *H.S.*
Valsaria insitiva Ces. and de Not. *D.*
Diatrypella quercina (Pers.) Nits. *S.*
Diatrype stigma (Hoffm.) de Not. *H.*, disciformis (Hoffm.) Fr. *P.*
Hypoxylon multiforme Fr. *S.H.*, coccineum Bull. *S.P.M.*
Daldinia concentrica (Bolt.) Ces. and de Not. *H.*
Ustulina vulgaris Tul. *H.*
Xylaria Hypoxylon (L.) Grev. *H.S.P.D.*, polymorpha (Pers.) Grev. *D.*
Phyllachora graminis (Pers.) Fuck. *P.*, Junci (Fr.) Fuck. *H.*
Dothidella Ulmi (Duv.) Wint. *H.*

HYSTERIACEAE.

Hypoderma Rubi (Pers.) Schroet. *H.*
Lophodermium cladophilum (Lév.) Rehm. *H.*
Lophium mytillinum (Pers.) Fr. *H.*
Hysterographium Fraxini (Pers.) de Not. *S.*

MYRIANGIACEAE.

Myriangium Duriaei Mont. and Berk. (in sensu lato) *H.*

TUBERACEAE.

Elaphomyces granulatus Fr. *H.S.P.*, variegatus Vitt. *P.*

DISCOMYCETES.

Galactinia succosa (Berk.) Sacc. *P.*
Pachyella depressa (Phill.) Boud. (? Humaria oocardii (Kalch.) Sacc.) *H.P.*
Peziza aurantia Pers. *H.*
Lachea erinacea (Schwein.) Sacc. *P.*
Ciliaria scutellata (L.) Quél. *S.*, setosa (Nees) Boud. *H.*
Cheilymenia stercorea (Pers.) Boud. *D.*, coprinaria (Cooke) Boud. *M.*
Coprobia granulata (Bull.) Boud. *D.*
Ascobolus furfuraceus Pers. *D.*, vinosus Berk. *P.D.*, viridulus Phill. and Plowr. *P.*, glaber Pers. *D.*
Dasyobolus immersus (Pers.) Sacc. *D.*
Saccobolus violascens Boud. *D.*
Ascophanus carneus (Pers.) Boud. *H.*, cervarius (Phill.) Boud. *H.*
Lasiobolus equinus (Mull.) Karst. *H.*, macrotrichus Rea *H.*
Rhyparobius crustaceus (Fuck.) Rehm. *D.*, myriosporus (Cr.) Boud. *H.*
Ascozonus argenteus (B. and Br.) Boud. *H.*
Geoglossum ophioglossoides (L.) Sacc. *P.*
Leotia lubrica (Scop.) Pers. *P.*

Cudoniella acicularis (Bull.) Schroet. *P.*
Ombrophila clavus (A. et S.) Cke. *H.*, alniella (Nyl.) Karst. *P.*
Calycella citrina (Hedw.) Quél. *H.*, claroflava (Grev.) Boud. *H* , ferruginea (Schum.) Boud. *H.*
Coryne sarcoides (Jacq.) Tul. *H.S.P.D.*
Bulgaria inquinans (Pers.) Fr. *H.S.D.*
Polydesmia pruinosa (B. and Br.) Boud. *H.P.*
Orbilia vinosa (A. and S.) Karst. *H.*, coccinella (Somm.) Fr. *P.*, leucostigma Fr. *H.S.P.*, xanthostigma Fr. *P.D.*
Sclerotinia Curreyana (Berk.) Karst.—sclerotia (Sclerotium roseum Moug.) only *S.*
Phialea firma Pers. *H.S.P.*
Chlorosplenium aeruginosum (Oeder.) de Not. *D.*, versiforme (Pers.) de Not. *H.*
Helotium herbarum (Pers.) Fr. *S.D.*, phyllophilum (Desm.) Karst. *D.*, fructigenum (Bull.) Fuck. *S.*, virgultorum (Wahl.) Karst. *H.*, melleum B. and Br. *H.*, moniliferum (Fuck.) Rehm. *D.*
Belonidium vexatum de Not. *H.*
Dasycypha virginea (Batsch) Fr. *H.*, nivea (Hedw. f.) Sacc. *D.*, scintillans Mass. *D.*, ciliaris (Schrad.) Sacc. *D.*, diplocarpa Curr. *H.*
Erinella juncicola (Fuck.) Sacc. *S.*
Lachnella corticalis (Pers.) Fr. *D.*, prasina Quél. *H.*
Trichoscypha calycina (Schum.) Boud. *H.P.*
Hyaloscypha punctiformis (Grev.) Boud. *D.*, dentata (Pers.) Boud. *D.*
Mollisia fallax (Desm.) Gill. *D.*, aquosa (B. and Br.) Phill. *D.*, discolor (Mont. and Fr.) Phill. *P.*, cinerea (Batsch) Karst. *H.S.P.*, ventosa Karst. *D.*
Pseudopeziza Trifolii (Biv.-Bern.) Fuck. *M.*
Stegia Ilicis Fr. *H.S.P.D.*
Rhytisma acerinum (Pers.) Fr. *S.D.*, punctatum (Pers.) Fr. *D.*

PHYCOMYCETES.

Cystopus candidus (Pers.) de By. *S.*
Plasmopara nivea (Ung.) Schroet. *P.*
Bremia Lactucae Regel. *M.*
Peronospora Myosotidis de By. *P.*, Viciae (Berk.) de By. *P.*, Trifoliorum de By. *M.*, Urticae (Lib.) de By. *D.*, parasitica (Pers.) Tul. *S.*, alta Fuck. *H.S.P.D.*
Mucor racemosus Fres. *S.*
Phycomyces nitens (Agardh.) Kunze *P.*
Spinellus fusiger (Link) van Tiegh. *H.S.*
Syzygites megalocarpus Ehrb. *H.*
Pilaira anomala (Ces.) Schroet. *D.*
Pilobolus crystallinus (Wigg.) Tode *D.*, longipes van Teigh. *S.*
Piptocephalis Freseniana de By. *S.*
Protomyces macrosporus Ung. on *Aegopodium Podagraria M.*

SPHAEROPSIDEAE.

Phyllosticta Berberidis Rabh. *D.*, maculiformis Sacc. *P.D.*, Bolleana Sacc. *M.*, fraxinicola Curr. *H.*, Mahoniae Sacc. and Speg. *D.*, leptidea (Fr.) Allesch. *H.*, Brassicae (Curr.) Westend. *S.*
Phoma conigena Karst. *H.P.*, strobiligena Desm. *H.*, samararum Desm. *H.*
Cytospora Lauro-cerasi Fuck. *D.*
Actinonema Rosae (Lib.) Fr. *M.S*
Septoria graminum Desm. *M.*, Hederae Desm. *H.D.*, Rubi Westend. *H.S.P.*, thecicola B. and Br. on *Polytrichum* capsules *H.*, Violae Westend. *H.*

HYPHOMYCETES.

Oidium erysiphoides Fr. *H.S.P.D.*, alphitoides Griff. and Maub. *H.S.P.D.* on *Fagus D.*, Euonymi-Japonicae Salm. *M.*
Botryosporium pulchrum Corda *D.*
Rhinotrichum Thwaitesii B. and Br. *S.*
Sepedonium chrysospermum (Bull.) Fr. *H.S.P.D.*

Ovularia obliqua (Cooke) Oud. *H.S.P.D.*, primulana Karst. *H.*
Meria Laricis Vuill. *H.*
Botrytis cinerea Pers. *H.S.*
Verticillium agaricinum (Link.) Corda *S.*, epimyces B. and Br. *S.*
Trichothecium roseum Link *P.*
Arthrobotrys superba Corda *D.*
Ramularia Urticae Ces. *S.D.*, acris Lindr. *D.*, lactea (Desm.) Sacc. *H.S.*, Primulae v. Thum. *H.S.*, calcea (Desm.) Ces. *H.S.D.*, plantaginea Sacc. and Berl. *S.D.*, sambucina Sacc. *H.*, Cirsii Allesch. *P.*, Hypochoeridis Mag. *P.*, Taraxaci Karst. *M.*
Cladosporium herbarum (Pers.) Link. *H.S.*, epiphyllum (Pers.) Mart. *H.D.*
Cercospora Mercurialis Passer. *H.*
Bispora monilioides Corda *D.*
Stilbella erythrocephala (Ditm.) Lind. *D.*, fimetaria (Pers.) Lind. *D*
Tilachlidium tomentosum (Schrad.) Lind. *H.*
Isaria farinosa (Dicks.) Fr. *H.S.P.*
Aegerita candida Pers. *H.*

MYCETOZOA FOUND DURING THE MINEHEAD FORAY.

By G. Lister, F.L.S.

The visit of the British Mycological Society to Minehead was arranged to extend from Monday, September 27th to Saturday, October 2nd; several of our members however arrived a few days earlier and remained a few days later than the appointed time. In hunting for Mycetozoa a good average result was obtained.

The weather had been on the whole fine and dry for some weeks previously, and this perhaps accounted for an even richer harvest not having been made. The sheltered woods lying among the folds of Exmoor and the hills of the coast are known to be favourable to Mycetozoa from the researches of Mr N. G. Hadden, who resides in the district, and who, in the past few years, has found there over a hundred species. Thanks to his guidance we were conducted to good hunting grounds.

On Tuesday, September 28th, we visited Horner Woods, below Dunkerry Beacon; these consisted chiefly of oak, ash and holly with undergrowth of bracken, bramble and moist grass in the valleys, and heather on higher ground. Among the more interesting specimens obtained was *Didymium dubium*, and a large but weathered growth of *Physarum leucopus*, both on dead holly leaves. *Fuligo muscorum* was found on heather in two places, in the apricot plasmodium stage; on being brought

indoors it soon developed into the characteristic small compact aethalia. A fresh growth of shining black sporangia of *Hemitrichia Vesparium* was obtained on the same dead tree where it had been found more or less abundantly for the last four years. *Hemitrichia clavata* has occurred also on this tree, but was not in evidence on the present occasion.

On Wednesday, September 29th, the party drove to Selworthy. Here extensive woods of oak, holm oak, and ash, with some conifers, clothe the south side of the coast hills; in many parts there is undergrowth of Rhododendron and bramble. Large developments of *Physarum bitectum* were found within bramble thickets, together with a curious form of *Diderma effusum* with small depressed pale brown and much wrinkled sporangia. *Dictydium cancellatum* and *Licea flexuosa* were obtained on coniferous wood.

Thursday, September 30th, when the fine woods above Porlock were visited, was wet. The trees consisted of oak, ash, holly, walnut, and some Scots pine and larch; with undergrowth of fern, grass and, on higher ground, heather. On the surface of a large sawdust heap a quantity of the white plasmodium of *Arcyria denudata* was emerging. A handsome growth of *Trichia Botrytis* forma *cerifera* was found on a log half submerged in water. When still moist, the black sporangia were seen to be distinctly mottled with translucent yellow patches, so that at a glance it was referred to this variety. When dry, however, only about half a dozen sporangia exhibit the bright yellow warts of wax characteristic of the variety; the remaining sporangia are either purple-black veined with glossy red-brown lines of dehiscence, or opaque purple-black mottled with glossy yellowish areas, due probably to thin deposits of wax. An interesting feature of these black sporangia is that their dark colour is in part caused by dense deposits of dark plasmodic granules each about 1 μ diam., lying between the two layers of the sporangium-wall; such granules have been usually considered to occur only in sporangia of the Order *Heterodermaceae*, including the genera *Cribraria*, *Dictydium* and *Lindbladia*; they have not been seen in the brown or rosy forms of *Trichia Botrytis*, nor are they present in black sporangia of *Trichia floriformis*.

On Friday, October 1st, the grounds of Dunster Castle were visited. In a wood-yard *Perichaena depressa*, found on elm logs, proved to be a new record for Somerset; the beds of old sawdust were teeming with plasmodium of *Fuligo septica*.

Saturday, October 3rd. Some of our party again went to the Horner Woods and Porlock, where among other species *Stemonitis splendens* var. *flaccida* and a single sporangium of *Colloderma oculatum* were found.

Two days before we assembled Mr Hadden had obtained *Lamproderma arcyrionema* and *Trichia favoginea* in Porlock Woods, and soon after we left he found there *Enteridium olivaceum, Stemonitis hyperopta, Cribraria pyriformis* and *Arcyria Oerstedtii*, all new to the district, the three last species were on sawdust heaps. *Cribraria pyriformis* is rare in England, having only been met with once before in its typical form; Dr W. T. Elliott obtained it in the New Forest near Lyndhurst in December 1916. The var. *notabilis* has been found several times in Ashdown Forest, Sussex, on sawdust heaps, by Mr W. E. Nicholson. In Scotland *C. pyriformis* has been obtained repeatedly.

In the following list *H.* refers to Horner Woods; *S.* to Selworthy; *P.* to Porlock Woods and *D.* to Dunster.

Ceratiomyxa fruticulosa (Müll.) Macbr. *H.S.*
Badhamia utricularis (Bull.) Berk. *H.D.*
B. panicea (Fries) Rost. *D.*
Physarum leucopus Link *H.*
P. nutans Pers. *H.S.P.D.*
P. viride (Bull.) Pers. *P.D.*
P. bitectum Lister *H.S.*
Fuligo septica (L.) Gmel. *H.P.D.*
F. muscorum Alb. and Schw. *H.*
Craterium minutum (Leers) Fries *H.S.P.D.*
Leocarpus fragilis (Dicks.) Rost. *H.D.*
Diderma deplanatum Fries *H.D.*
D. effusum (Schw.) Morg. *H.S.*
Didymium difforme (Pers.) Link *S.P.*
D. dubium Rost. *H.P.*
D. squamulosum (Alb. and Schw.) Fries *H.S.P.D.*
D. nigripes Fries *S.D.*
D. nigripes var. xanthopus Lister *H.S.*
Colloderma oculatum (Lipp.) G. Lister *P.*
Stemonitis fusca Roth. *H.S.P.*
S. splendens Rost. var. flaccida Lister *P.*
Stemonitis hyperopta Meylan (Syn. Comatricha typhoides var. heterospora Rex.) *P.*
Lamproderma scintillans (Berk. and Br.) Morg. *P.*
L. arcyrionema Rost. *P.*
Comatricha nigra (Pers.) Schroet. *H.S.*
Cribraria argillacea Pers. *S.D.*
C. rufa (Roth.) Rost. *P.*
C. vulgaris Schrad. *D.P.*
C. pyriformis Schrad. *P.*
Dictydium cancellatum (Batsch) Macbr. *S.P.*
Licea flexuosa Pers. *H.S.P.*
Tubifera ferruginosa Gmel. *S.*
Enteridium olivaceum Ehrenb. *P.*
Reticularia Lycoperdon Bull. *H.S.*
Lycogala epidendrum (L.) Fries *H.P.*
Trichia favoginea Pers. *P.*
T. affinis de Bary *H.S.P.*
T. persimilis Karst. *H.S.D.*
T. varia Pers. *H.S.P.D.*
T. Botrytis Pers. *H.P.* forma cerifera Lister *P.*
T. decipiens (Pers.) Macbr. *S*
Hemitrichia Vesparium (Batsch) Macbr. *H.*
Arcyria denudata (L.) Wettst. *H.S.*
A. incarnata Pers. *H.S.*
A cinerea (Bull.) Pers. *H.P.*
A. nutans (Bull.) Grev. *H.*
A. Oerstedtii Rost. *P.*
Perichaena depressa Lib. *D.*
P. corticalis (Batsch) Fr. *H.*

This list of 49 species is the third largest that has been obtained on one of our forays; the two larger being those from Forres (81) and from Selby (51).

MYCETOZOA AT PORLOCK IN OCTOBER 1920.

By Norman G. Hadden.

A dry September with frequent cold winds had rendered the local woods much too dry for an abundant growth of Mycetozoa at the time of the British Mycological Society's Foray at Minehead, so that the wealth of species known to occur was but poorly represented. The very heavy rains which fell during the first week of October, followed by warm dull days with thick mists in the early morning provided ideal conditions for the development of sporangia of Mycetozoa. Two and three-year old heaps of coniferous sawdust which had been under observation all the summer and had yielded no specimens, quickly became the centre of interest and were bespangled with large masses of maturing plasmodium. The crimson and grey sporangia of *Arcyria denudata* and *A. cinerea* appeared in great abundance and were soon accompanied by a large semi-circular patch of white plasmodium which proved to be the very beautiful *Arcyria Oerstedtii*. All of this development which remained exposed on the sawdust was completely destroyed by a heavy rain storm; fortunately I had brought a quantity of it in-doors where the formation of the sporangia and change from white to ochraceous brown and finally to rich crimson was extremely interesting to observe. Sawdust developments are more at the mercy of the elements and become mouldy sooner than the ordinary growths matured on dead logs or fallen branches which afford them a certain amount of protection, but on the other hand the growths on sawdust are usually larger and more luxuriant. Two small developments of the lilac-brown *Stemonitis hyperopta* was a somewhat unexpected find on the sawdust. Another sawdust heap situated about 900 ft. above sea level proved of great interest; large masses of the little nut-brown *Cribraria aurantiaca* carpeted its surface intermingled with *Dictydium cancellatum* in smaller quantity. The green strands of plasmodium of the Cribraria were very conspicuous as they crept over the sawdust when about to mature. Chips of larch wood lying on the heap provided a home for quantities of the black *Licea flexuosa*, the dark olive-green aethalia of *Enteridium olivaceum* and a fine growth of the rare and handsome *Cribraria pyriformis* which appears to be particularly partial to these old heaps of coniferous sawdust. Heavy rain again fell in the middle of the month succeeded by somewhat cold and dull weather; from this time all sawdust developments ceased to appear but logs, dead gorse twigs, hedge

clippings etc. began to bear a rich harvest of Mycetozoa of many species. *Physarum pusillum* and *Comatricha tenerrima* appeared together in some quantity on decaying stems of *Oenanthe crocata* in a very wet copse. *Didymium Clavus* studded old gorse twigs with hundreds of grey nail-like sporangia, even exceeding the goblets of *Craterium minutum* in their profusion.

The bare and wind-swept valley known as Smallacombe has proved to be the habitat of a number of interesting species; its steep sides have been denuded of all trees for several years and the only shelter is afforded by heather, mountain fern and small whortleberry bushes. The lowest slope is always moist and covered with a rich growth of mosses down to the path-side, amongst which nestle the dainty ivy-leafed Campanula, bog pimpernel and Cornish moneywort. Facing north-west, it is a cold and draughty combe even in summer since the winds either sweep up it from the sea or blow down it directly from the Exmoor plateau. On October 23rd I noticed a fine development of the sessile sporangia of *Diderma ochraceum* on wet moss at the foot of the combe and a hurried search soon revealed many more large growths of this very uncommon species, sometimes sheltering under heather but more often fully exposed on the moss. Fresh developments were in all stages of growth from the lemon-yellow plasmodium to ochraceous ripe sporangia; the following week they were still appearing but now accompanied by masses of orange plasmodium developing into the inconspicuous though sturdy sporangia of *Lepidoderma tigrinum*. As these two species have frequently been found in association (possibly there may be some connection between them not as yet understood) it was particularly interesting to be able to study their growth side by side; the lemon plasmodium always produced the sessile ochraceous sporangia and the orange plasmodium as constantly developed into stout stalked deep olive sporangia with the characteristic white crystalline discs. Although the moss was teeming with plasmodia I never found the lemon and orange veins touch one another or mature upon the same stem. Associated with the Diderma and Lepidoderma were a number of small short-stalked sporangia of *Lamproderma columbinum* very closely resembling *L. violaceum* in habit and quite different in appearance to the handsome long-stalked large sporangia of typical *L. columbinum* which had appeared in a three-inch wide mass on short moss near by. This is the usual form in the Porlock district and is not infrequent in winter on bare soil by wet woodland tracks. It is interesting to note that whereas *Lepidoderma tigrinum* is usually only found on wet moss or very rotten wood I have recently seen it in fine condition on Polytrichum growing on a stony slope in CulboneWood

where this moss and *Sedum anglicum* were almost the only plants which had succeeded in obtaining a roothold amongst the scree. Some rotten pine and larch logs lying on the hillside above Smallacombe were covered with rich growths of *Colloderma oculatum*, *Enerthenema papillatum*, *Comatricha elegans*, *Stemonitis ferruginea*, *S. herbatica* (with very lax capillitium), *Licea flexuosa* and a small development of *Dianema corticatum*, a species which does not appear to have been obtained in southern England previously. It so closely resembles *Licea flexuosa* in the field that it is easily overlooked, but the pinkish colour of the spores in mass (instead of olive) is a help in recognising it. On very wet moss by a spring side *Fuligo muscorum* appeared, one inconspicuous ripe aethalium along with the more showy apricot plasmodium which matured in-doors after a couple of days. On an old ash tree growing near the mouth of the combe I detected several of the tiny grey hemispherical sporangia of *Badhamia affinis* perched among tufts of Orthotrichum and Frullania some five feet from the ground. As each sporangium grows by itself it is by no means conspicuous, but though only recorded in Britain from Aberdeenshire and Cornwall it is quite likely to be found anywhere when carefully searched for, nearly all the arboreal Mycetozoa being inconspicuous but evidently of wide distribution. Similarly it is not likely that Japan, West Somerset and Aberdeenshire are the only localities for the typical *Hemitrichia minor*! It seems impossible to lay down any rules as to searching for the arboreal species; most of Mr Cran's wonderful Scottish finds have been upon exposed trunks sparsely clad with lichen and moss, here my only success has been on ash trees in damp sheltered woods where mosses and lichens luxuriate on the bark. On the same tree which yielded *B. affinis* I collected some freshly emerged lemon-yellow sessile sporangia growing on moss low down on the trunk; by the time I reached home these sporangia had turned a dull green, the next morning they were a bright grass green; they finally matured into the yellow plasmodiocarps of the rare *Badhamia nitens* var. *reticulata*.

While gathering these interesting Mycetozoa it was a never-failing source of pleasure to listen to the belling of red deer stags, eager for a battle with a rival from some distant combe, to the hoarse croaking of ravens and the wild mewing cries of buzzards as they soared high overhead.

Since the above was written I have had the pleasure of finding about thirty sporangia of the remarkable *Diachaea cerifera* G. Lister (see Journal of Botany, vol. LI, Jan. 1913). The white plasmodium and newly developed sporangia occurred on the Hepatic *Pellia epiphylla* on a steep bank close to a small stream

in the wood above Porlock Weir. The dark purplish-brown iridescent sporangia are seated on stout yellowish stalks and are very similar in appearance to the specimens obtained by M. Meylan in the Jura Mountains. This is the first British record of *D. cerifera*; it has hitherto only been found in Norway, Switzerland and Japan.

THE LICHENS OF MINEHEAD DISTRICT.

By H. H. Knight, M.A.

For the first time since the Mycological Society has included Lichens in its program the autumn foray was held in a district where these plants were plentiful. A further interest in Lichens was given by Mr Paulson's excellent account of "The Sporulating Gonidia of *Evernia prunastri*."

Horner Wood was particularly rich in arboreal species. This is an old wood, and not like a modern plantation where the trees are too closely packed to admit light for Lichens growing on their trunks. The well known *Lobaria pulmonaria* was abundant, also *Nephromium lusitanicum* and three species of *Sticta*. Other conspicuous plants were *Synechoblastus nigrescens*, *Leptogium Burgessii*, and species of *Pannaria* and *Parmeliella*. *Thelotrema lepadinum* was plentiful on many of the hollies.

The woods at Selworthy and Porlock were less prolific, and more attention was given to the saxicolous species, which were found wherever rocks were exposed. In the wood at Dunster *Thelotrema* was again found on hollies; here too were *Enterographa crassa* and *Phaeographis dendritica* which were not seen at Horner.

At Minehead the shingle above high tide level, and rocks on the North Hill including Greenaleigh Point were examined. The rocks in the district were mostly Devonian sandstone, the calcareous species in the list being found on mortared walls.

For assistance in naming the Lichens in this list I am indebted to Dr Watson of Taunton and to Mr Paulson.

M. = Minehead. *H.* = Horner. *S.* = Selworthy. *P.* = Porlock. *D.* = Dunster. *f.* = fertile.

Calicium hyperellum Ach. *f.*, *H.*
Placynthium nigrum S. F. Gray *f.*, *M.H.D.*
Collema pulposum Ach. *f.*, *M.D.*
C. cheileum Ach. *f.*, *D.*
Synechoblastus nigrescens Anzi *H.*
S. rupestris A. L. Sm. *H.*
Leptogium lacerum S. F. Gray *f.*, *M.*; f. fimbriatum Nyl. *f.*, *H.*
L. Burgessii Mont. *f.*, *H.*

Parmeliella corallinoides A. Zahlbr. *f.*, *H.*
P. plumbea Wain. *f.*, *H.*
Pannaria rubiginosa Del. var. conoplea Koerb. *H.*
P. nebulosa Nyl. *f.*, *H.*
Peltigera canina Willd. *f.*, *H.*
P. rufescens Hoffm. *H.*; var. praetextata Nyl. *H.*
P. horizontalis Hoffm. *f.*, *M.*
Nephromium lusitanicum Nyl. *f.*, *H.*
Sticta fuliginosa Ach. *H.*
S. sylvatica Ach. *H.*
S. limbata Ach. *H.*
Lobaria pulmonaria Hoffm. *H.*
Parmelia physodes Ach. common.
P. perlata Ach. *P.D.*
P. caperata Ach. *H.D.*
P. saxatilis Ach. *M.S.*; f. furfuracea Schaer. *S.*
P. sulcata Tayl. *P.D.*
P. dubia Schaer. *H.D.*
P. revoluta Floerke *H.P.*
P. conspersa Ach. *M.*
P. fuliginosa Nyl. *M.S.*; var. laetevirens Nyl. *P.D.*
Evernia prunastri Ach. common.
Ramalina fastigiata Ach. *f.*, *M.D.*
R. farinacea Ach. *S.P.*
R. siliquosa A. L. Sm. *M.*
Usnea florida Web. *f.*, *H.*; var. hirta Ach. *H.*
Xanthoria parietina Th. Fr. *f.*, common; var. ectanea Oliv. *M.*
Placodium callopismum Mér. *f.*, *D.*
P. murorum DC. *f.*, *M.P.D.*
P. lobulatum A. L. Sm. *f.*, *M.*
P. citrinum Hepp. *f.*, *M.H.P.*
P. rupestre Branth and Rostr. *f.*, *D.*
Physcia pulverulenta Nyl. *f.*, *D.*
P. stellaris Nyl. var. cercidia Th. Fr. *f.*, *M.D.*
P. hispida Tuckerm. *D.*
P. orbicularis var. virella Dalla Torre and Sarnth. *M.*
Rinodina demissa Arn. *f.*, *M.S.*
Lecanora subfusca Ach. var. chlarona Ach. *f.*, *H.S.D.*; var. allophana Ach. *f.*, *H.*
L. rugosa Nyl. *f.*, *H.*
L. campestris B. de Lesd. *f.*, *H.D.*
L. coilocarpa Nyl. *f.*, *M.S.D.*
L. atra Ach. *f.*, common.
L. umbrina Massal. *f.*, *M.*
L. pallida Schaer. *f.*, *M.S.*
L. sordida Th. Fr. *f.*, *S.*
L. galactina Ach. *f.*, *M.D.*
L. conizaea Nyl. *f.*, *M.*
L. symmicta Ach. *f.*, *H.S.P.*
L. polytropa Schaer. *f.*, *M.S.*
L. parella Ach. *f.*, common.
L. cinerea Sommerf. *f.*, *M.*
L. calcarea Sommerf. *f.*, *D.*
Acarospora fuscata Th. Fr. *f.*, *S.*
A. smaragdula Massal. f. rufescens (Turn.) *f.*, *S.*
Lecania erysibe Mudd. *f.*, *M.*
Pertusaria faginea Leight. *H.S.D.*
P. lactea Nyl. *M.S.*
P. pertusa Dalla Torre and Sarnth. *f.*, *H.D.*
P. ceuthocarpa Turn. f. microstictica Cromb. *S.*
P. dealbata Cromb. *H.S.*
P. leioplaca Schaer. *f.*, *H.P.D.*
P. Wulfenii DC. *f.*, *H.P.*
Thelotrema lepadinum Ach. *f.*, *H.D.*
Phlyctis agelaea Koerb. *D.*
Baeomyces rufus DC. *f.*, *M.P.*
Cladonia sylvatica Hoffm. *H.S.*
C. foliacea Willd. *S.*
C. pyxidata Hoffm. *H.*
C. fimbriata Fr. *M.P.*; f. prolifera Retz. *P.*; var. simplex Wain. *D.*
C. pityrea Fr. *S.*
C. furcata Schrad. *S.*
C. flabelliformis Wain. *P.*; var. polydactyla Wain. *P.*
C. macilenta Hoffm. *D.*
C. Floerkeana Fr. *S.P.*
Lecidea quernea Ach. *f.*, *S.*
L. coarctata Nyl. *f.*, *S.*; var. elacista Cromb. *f.*, *S.*
L. uliginosa Ach. *f.*, *S.*
L. fuliginea Ach. *f.*, *D.*
L. protrusa Fr. *M.*
L. parasema Ach. *f.*, common; var. elaeochroma Ach. *f.*, *H.D.*
L. latypea Ach. *f.*, *S.*
L. contigua Fr. *f.*, common.
L. crustulata Koerb. *f.*, *M.H.*
L. sorediza Nyl. *P.*
L. rivulosa Ach. *f.*, *M.S.*
L. sylvicola Flot. var. infidula Cromb. *f.*, *H.S.*
Biatorella pruinosa Mudd f. nuda A. L. Sm. *f.*, *D.*
Biatorina littorella A. L. Sm. *f.*, *M.*
B. pilularis Koerb. *f.*, *H.*
B. atropurpurea Massal. *f.*, *H.*
B. lenticularis Koerb. *f.*, *M.P.*
Bilimbia aromatica Jatta, *f.*, *M.D.*
B. sabuletorum Branth and Rostr. *f.*, *M.*
Bacidia umbrina Branth and Rostr. *f.*, *P.*
Buellia canescens De Not. *M.P.D.*
B. spuria Koerb. *f.*, *S.*
B. myriocarpa Mudd, *f.*, *D.*
B. subdisciformis Jatta, *f.*, *M.*
B. coniops Th. Fr. *f.*, *M.*
B. confervoides Kremp. *f.*, *M.*
Rhizocarpum alboatrum Th. Fr. var. epipolia A. L. Sm. *f.*, *P.*

R. geographicum DC. *f.*, *M.S.*
R. viridiatrum Koerb. *f.*, *M.S.*
R. petraeum Massal. *f.*, *M.*
R. confervoides DC. *f.*, *M.S.P.*
Lecanactis premnea Weddell *f.*, *H.*
L. abietina Koerb. *f.*, *H.*
Arthonia lurida Ach. *f.*, *S.D.*
A. gregaria Koerb. *f.*, *H.*
A. radiata Ach. *f.*, *H.*; var. Swartziana Sydow, *f.*, *H.*
Lithographa dendrographa Nyl. *f.*, *H.*
Opegrapha atra Pers. *f.*, common; var. denigrata Schaer. *f.*, *S.*
O. varia Pers. *f.*, *P.*
O. vulgata Ach. *f.*, *H.D.*; var. siderella Nyl. *f.*, *H.*
Graphis elegans Ach. *f.*, *P.D.*; f. coacervata Leight. *f.*, *H.*
G. scripta Ach. *f.*, *H.*
Phaeographis inusta Muell.-Arg. *f.*, *H.*
P. dendritica Muell.-Arg. *f.*, *D.*
Enterographa crassa Fée *f.*, *D.*
Dermatocarpum aquaticum A. Zahlbr. *f.*, *H.S.*
Verrucaria maura Wahlenb. *f.*, *M.*
V. aquatilis Mudd *f.*, *D.*
V. margacea Wahlenb. *f.*, *P.*
V. submersa Schaer. *f.*, *H.P.*
V. viridula Ach. *f.*, *P.D.*
V. nigrescens Pers. *f.*, *H.*
V. glaucina Ach. *f.*, *M.*
V. maculiformis Krempelh. *f.*, *M.*
V. muralis Ach. *f.*, *P.*
Thelidium Nylanderi Krempelh. *f.*, *P.*
Acrocordia gemmata Koerb. *f.*, *H.P.*
A. biformis Oliv. *f.*, *H.S.*
A. epipolaea A. L. Sm. *f.*, *P.*
Arthopyrenia epidermidis Mudd *f.*, *H.P.*
A. punctiformis Arn. *f.*, *M.*
A. fallax Arn. *f.*, *H.P.*
Porina carpinea A. Zahlbr. *f.*, *P.*
Pyrenula nitida Ach. *f.*, *H.S.D.*

The following Fungus parasites were found on Lichens:

Ticothecium erraticum Massal. on Lecanora cinerea *M.*
Ticothecium rimosicolum Arn. on Rhizocarpum petraeum *M.*
Spegazzinia sp. on Pertusaria dealbata *S.*

PRESIDENTIAL ADDRESS.

By T. Petch, B.A., B.Sc.

FUNGI PARASITIC ON SCALE INSECTS*.

The earliest record of a fungus parasitic on a scale insect was made by Desmazières in 1848†. His specimens were collected at Caen, in Normandy, growing on scale insects on willow and ash. He instituted for it a new genus, *Microcera*, and gave a fairly complete description, emphasising the fact that the fungus was enclosed in a veil or sheath which divided into teeth at the apex. *Microcera* may be said to be a *Stilbum*, which has Fusarioid conidia, and is enclosed in a sheath which partly envelopes the head of conidia. Desmazières was so impressed by the structure and habitat of his species that he added to the formal description a long account of it in which he allowed his imagination free rein and compared *Microcera* to a phalloid.

Desmazières' species was next described by the Tulasnes in

* From the mycological standpoint, it is convenient to include the fungi parasitic on Aleyrodidae with those on the true scale insects (Coccidae).

† Ann. Sci. Nat., Ser. 3, 1. (1848), p. 359.

1861*. They did not find the universal veil, and stated that the apparent veil was merely a covering of mycelium at the base of the stroma. It would seem that they were misled by Desmazières' use of the term volva, and his comparison with a phalloid, and expected to find a structure resembling a phalloid volva at the base of the clava. It is difficult to make out the structure of *Microcera* from European examples.

Desmazières' fungus, *Microcera coccophila*, was a conidial form. To it the Tulasnes attached a perithecial stage, which was collected in company with a similar conidial stage at Florence. The perithecial stage was a *Nectria*, and consequently the Tulasnes placed the fungus in their genus *Sphaerostilbe*, under the name *Sphaerostilbe coccophila*. It is to be noted that the type locality for the perithecial stage is Florence, Italy, and that of the conidial stage, Caen, France.

The next record of a *Nectria* on a scale insect was made by Berkeley and Broome in the Fungi of Ceylon (1873)†, in which they described *Nectria aurantiicola*, with the note, "apparently growing from some coccus." Berkeley and Broome described the Fusarioid conidia and figured the effete Stilboid stage dividing into teeth at the apex; consequently, one is rather at a loss to understand why they did not place their species in *Sphaerostilbe*.

Two years later‡, Berkeley and Curtis described *Nectria aglaothele* from North America, with a note that it grew on the remains of a coccus. This again is *Sphaerostilbe*.

In 1901, Zimmermann described *Nectria coccidophthora*§, on scale insects in Java. This differs from *Nectria aurantiicola*, principally in its larger ascospores, and must be classed with the latter species in *Sphaerostilbe*.

So far the record is quite straightforward. Four species referable to *Sphaerostilbe* have been described as occurring on scale insects. But naturally, the idea that fungi might be parasitic on scale insects, and not on the plant on which they were found, was not always in mind, and hence it is only to be expected that, when the presence of the scale insect was not immediately obvious, such fungi would be described without reference to their real host. An examination of the species of *Nectria* and *Sphaerostilbe* in the herbaria at Kew and the British Museum has confirmed that supposition.

Prior to *Sphaerostilbe coccophila*, the Tulasnes had described a species with a similar conidial stage as *Sphaerostilbe flammea*. The history of the latter species begins in England, with speci-

* Selecta Fungorum Carpologia, I, p. 130; III, p. 105.
† Journ. Linn. Soc. XIV (1873), p. 117.
‡ Grevillea, IV (1875), p. 45.
§ Centralb. f. Bakt., Abt. II, VII (1901), p. 873.

mens collected by Ralfs at Penzance on living willows. These were described by Berkeley in 1854 as *Atractium flammeum* Berk. and Rav.*, the fungus having been found in similar situations, peeping up from beneath lichens, by Ravenel in South Carolina. Berkeley noted that Ravenel suspected it to be the state of some *Nectria*, and the herbarium specimens show that Ravenel had suggested that it was a stage of *Nectria muscivora* B. and Br.

Nectria muscivora was described by Berkeley and Broome† in 1851. It was parasitic on mosses at Kings Cliffe. To the description they added the note that they had the species from South Carolina on *Jungermannia*. There is an abundance of American specimens from Ravenel available in Herb. B.M. and Herb. Kew, under *Nectria muscivora*, and also others of the same species, either conidial, or conidial and perithecial, under *Atractium flammeum*, *Sphaerostilbe flammea*, and *Microcera coccophila*, identified by Berkeley or Ravenel.

Berkeley sent specimens of *Atractium flammeum* to the Tulasnes, and these proved to bear *Nectria* perithecia. Consequently the Tulasnes described it, first under the name *Stilbum flammeum*‡, and later as *Sphaerostilbe flammea*§. According to the Tulasnes, the specimens sent to them were American, though they stated that they grew on willow, which was the English host plant. Here we have another case in which the type locality for the conidial stage is in one country and the type locality for the perithecial stage in another.

This species was described again as *Nectria laeticolor* by Berkeley and Curtis in 1868‖; as *Nectria aglaothele* by the same authors in 1875¶, as *Nectria subcoccinea* by Saccardo and Ellis in 1882**, and as *Nectria Passeriniana* by Cooke in 1884††.

Ellis and Everhart discovered that *Nectria subcoccinea* was the same as Ravenel's specimens which had been attributed to *Nectria muscivora*, and they drew up their description of the latter species from specimens which had been distributed by Ellis as *Nectria subcoccinea*‡‡. But they did not see Berkeley and Broome's type of *Nectria muscivora*, and consequently were unaware that the original determination of Ravenel's specimens as *Nectria muscivora* was incorrect. That leaves *Sphaerostilbe flammea* as the earliest name for Ravenel's species, which is

* Ann. Mag. Nat. Hist., Ser. II, XIII (1854), p. 461.
† Ann. Mag. Nat. Hist., Ser. II, VII (1851), p. 188.
‡ Acta Hebdom. Acad. Sci. par. XLII, p. 704, and Ann. Sci. Nat., Ser. 4, V (1856), p. 114.
§ Selecta Fung. Carp. I, p. 130; III, p. 104.
‖ Journ. Linn. Soc. X, p. 377 (1868).
¶ Grevillea, IV (1875), p. 45.
** Michelia, II (1882), p. 570.
†† Grevillea, XII (1884), p. 81.
‡‡ North American Pyrenomycetes (1892).

not parasitic on mosses and lichens, but on scale insects which in some instances occur beneath mosses and lichens.

We have now to reconsider the species which has always been recognised to be parasitic on scale insects, viz. *Sphaerostilbe coccophila* Tul. This, it will be remembered, was instituted on a conidial stage, *Microcera coccophila*, collected in Normandy and a perithecial stage collected in Italy. Specimens of both these collections are available, and in both cases they contain perithecia. But the perithecia which accompany *Microcera coccophila* are not the same as those collected in Italy. The former are the perithecia of *Sphaerostilbe flammea*, while the latter are the species described from Ceylon by Berkeley and Broome as *Nectria aurantiicola*. Consequently *Microcera coccophila* Desm. is the conidial stage of *Sphaerostilbe flammea*, and *Atractium flammeum* is a synonym, while Tulasnes' *Sphaerostilbe coccophila* consists of the perithecia of one species and the conidial stage of another.

One has considerable hesitation in proposing to abolish a name which has become so firmly established in the literature of economic mycology. But *Sphaerostilbe coccophila* is a compound species and its name was admittedly selected on the mistaken supposition that the perithecia described were related to *Microcera coccophila*. In any case, *Microcera coccophila* must be retained for the conidial stage of *Sphaerostilbe flammea*, and it would be very confusing to retain the same specific name for the perithecial stage of a different *Sphaerostilbe*.

We have therefore three species of *Sphaerostilbe* parasitic on scale insects, viz. *Sphaerostilbe flammea*, *Sphaerostilbe aurantiicola*, and *Sphaerostilbe coccidophthora*. In their conidial, *Microcera*, stages, these are all very similar and it is scarcely possible to define any constant distinguishing characters. But their perithecia are sufficiently distinct to maintain them as different species.

Species of *Sphaerostilbe* on scale insects would appear to be rare in Europe. The European material available in English herbaria is fairly abundant, but it is the product of very few gatherings. Perhaps the position may be similar to that of *Hypocrella* and *Aschersonia* in the Tropics, i.e. the fungus only required to be looked for. Moreover, to one who has collected *Sphaerostilbe* on scale insects in the Tropics, all the temperate collections appear very poorly developed, especially as regards the *Microcera* stage. *Microcera coccophila* in Europe and the Northern United States usually does not exceed half a millimetre in height, but in the type of *Microcera pluriseptata* from Brazil, which is identical with *Microcera coccophila*, the synnemata attain a height of 2·5 mm.; and the same difference is

seen between *Microcera aurantiicola* from Italy and Ceylon respectively. One gains the impression that the temperate gatherings are depauperate examples of species which have wandered out of their proper latitude.

According to the specimens which I have been able to examine, the distribution of these species of *Sphaerostilbe* is as follows.

Sphaerostilbe flammea is chiefly an American species. It has been found in the United States—Massachusetts, Pennsylvania, Georgia, South Carolina, Louisiana, Florida and Texas—in Cuba, Brazil, and Argentina; in England, in the neighbourhood of Penzance; in Normandy in France; and in Liguria in Italy (*Nectria Passeriniana*). Conidial specimens from South Africa, Australia, and New Zealand appear to belong to this species but no perithecia are available; the first of these were described as *Fusarium coccinellum* (Kalch.) Thuem.*

Sphaerostilbe aurantiicola would appear to be the common species of the tropics, extending occasionally into temperate countries. I have examined specimens from Ceylon, India, Formosa, Japan, Madagascar, the West Indies, Georgia, Florida, and Italy.

Sphaerostilbe coccidophthora is at present known only from Java, Ceylon, India, and the Seychelles.

In general, these species of *Sphaerostilbe* are parasitic on *Lepidosaphes* (*Mytilaspis*), *Aspidiotus*, *Parlatoria*, *Diaspis*, *Chionaspis*, and allied genera of scale insects. They frequently occur on scale insects on Citrus, and it is to be expected that their natural distribution will have been extended by the transference of Citrus plants and fruits from one country to another.

Records of *Microcera coccophila*, and of *Microcera* in general, must all be regarded with caution, for the name *Microcera* has been employed to cover any conidial fungus with *Fusarium* spores which grew on a scale insect. One cannot, however, examine many gatherings of these conidial fungi before discovering that there are two common types which differ generically from one another. That fact was noted by Parkin† who characterised the difference by stating that the one form possessed an adherent sheath, while the other had a loose sheath. But Parkin, not having seen the European *Microcera*, referred the first of these, which is the true *Microcera*, to *Fusarium*, and the second to *Microcera*.

Microcera, in well-developed examples, has a *Stilbum*-like stalk composed of parallel hyphae, which separate at the apex, branch, and bear *Fusarium* conidia; the outer hyphae of the stalk are united into a continuous sheath, which is adherent to

* Thuemen, Mycotheca Universalis, No. 782.
† Annals R.B.G. Peradeniya, III (1906), p. 52.

the stalk, but separates into teeth and becomes free round the head of conidia; the sheath is inconspicuous, except after the conidia have been dispersed. The fructification is a synnema, and the genus falls in the *Stilbaceae*.

In the common form which has been confused with *Microcera*, the base of the fructification, in well-developed forms, is parenchymatous, and forms a more or less oval, red, cushion; at the upper edge of this there arises a ring of white teeth, like the margin of a Discomycete, but connivent, surrounding the apex of the cushion; the apex of the cushion bears closely packed conidiophores which produce *Fusarium* conidia. In this form, the sheath contrasts strongly with the base and, as a rule, is the most conspicuous feature of the fungus; it is not continuous with the basal cushion and differs in structure from the latter. The conidia of this form differ in shape from those of the species of *Microcera* which are parasitic on scale insects. This fructification must be classed in the *Tuberculariaceae*.

I have examined specimens of this form from Ceylon, India, Burma, Java, Mauritius, Australia, Formosa, the Philippines, West Africa, Grenada, Cuba, Florida, and Brazil. It has occurred on *Mytilaspis*, *Aspidiotus*, *Ischnaspis*, *Fiorinia*, and *Aonidia*. There are no constant differences between the specimens from different localities or on different scale insects, but the available specimens from West Africa have much longer conidia than those from other countries. As, however, the specimens, with few exceptions, are conidial only, it is perhaps advisable to regard the species as possibly a collective one. In America it has been referred to *Microcera coccophila*; in Formosa it has been named *Microcera Fujikuroi**; and from the Philippines, *Microcera Merrillii*†. As it is a common fungus, it is quite probable that it was named in the earlier days of mycology, without reference to its habitat. The earliest name yet discovered is that given it by Koorders in Java, viz. *Aschersonia Henningsii*‡. I propose to establish for this species a new genus, *Pseudomicrocera*, in which it will stand as *Pseudomicrocera Henningsii*.

In 1886 (?) Spegazzini described a *Nectria* which occurred on scale insects in Brazil as *Nectria coccorum*§, and in 1889, a second species, *Nectria coccogena*‖, from the same country. Through the kindness of Professor Spegazzini, I have been able

* Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, v, pt. 3 (March 1913), pp. 73–90.

† Ann. Myc. XII (1914), p. 576. ‡ Bot. Untersuchungen (1907), p. 213.

§ Fungi Guaranitici, Pug. I, No. 234, Anal. Soc. Cientif. Argentina, Buenos Aires.

‖ Fungi Puiggariani, No. 289, Bolet. de la Acad. Nacional de Ciencias de Cordoba, II (1889), p. 381.

to examine the type specimens of both these species; that of *Nectria coccorum* is immature, but it appears to me to be identical with *Nectria coccogena*. Both the type specimens show a *Pseudomicrocera* conidial stage which is identical with *Pseudomicrocera Henningsii*. In Ceylon, this *Nectria* has been collected on two occasions, in each case developing on the old stromata of *Pseudomicrocera Henningsii*, and I have an immature gathering from Mauritius. *Pseudomicrocera Henningsii*, therefore, is the conidial stage of a *Nectria*. But the earliest name yet discovered for this *Nectria* is *Nectria diploa* B. and C., which was given to specimens from Cuba in 1875.

In 1901, Nomura published a paper* on the Scarlet Fungus Disease of Scale Insects in Japan, describing the fungus as a new species, *Nectria coccophila*. His paper was written in Japanese and has been generally overlooked, but in 1913 it was summarised by Miyabe and Sawada in their account of the fungi parasitic on scale insects in Formosa. Nomura, apparently, did not leave any type specimen, and the identity of his species is uncertain. Miyabe and Sawada would appear to favour the view that it was the species which they assign to *Sphaerostilbe coccophila*, but Nomura's description agrees more closely with *Nectria diploa*.

In 1913, Sydow† described a new genus and species parasitic on a scale insect in Japan as *Coccidophthora variabilis*. Subsequently K. Hara‡, who had sent the fungus to Sydow, stated that the specimen consisted of two species, viz. a *Nectria* parasitic on the scale insect, and a second species parasitic on the *Nectria*, and he described the scale insect *Nectria* as *Nectria variabilis*. I have not been able to examine a specimen of this *Nectria*, but from the published figures and the description it would appear to be again *Nectria diploa*.

A number of species have been described as *Microcera*, nine of which were said to be parasitic on scale insects. It is evident that the genus requires revision from the systematic standpoint, but at present only the scale insect species have been critically examined. Fortunately, most of the types of the latter have been available.

In 1904, McAlpine described§ two species of *Microcera* parasitic on scale insects in Australia, viz. *Microcera tasmaniensis* and *Microcera Mytilaspis*. The types of these species have been kindly lent me by Mr C. C. Brittlebank, and examination shows that they are identical, the first being a younger development of the second. This species proves to be neither *Microcera* nor

* Imp. Agric. Exp. Sta., Rep. 18 (1901), p. 105.
† Ann. Myc., XI (1913), p. 263.
‡ Botanical Magazine, Tokyo, XXVIII (1914), p. 339.
§ Agric. Journ. Victoria, II (1904), pp. 646–648.

Pseudomicrocera. It consists, in its fully developed form, of a stalked pezizoid disc, which bears *Fusarium* conidia. I propose to make this the type of a new genus, *Discofusarium*, with the species *Discofusarium tasmaniense*. Mr Brittlebank has also furnished me with specimens which show that the perithecial stage of this species is a *Calonectria*.

Of the remaining species of *Microcera*, parasitic on scale insects, *Microcera Parlatoriae* Trabut*, *Microcera Tonduzii* Pat.†, and *Microcera curta* Sacc.‡ are *Fusarium*. *Microcera rectispora* Cooke and Massee§ is *Tetracrium*, the conidial stage of *Ophionectria* (? *coccicola*); Cooke protested‖ that he made this species only in deference to the current opinion that minute differences in the spores were specific, but it would be difficult to imagine anything more different from *Microcera* than this.

In 1918, Stevenson¶ described another type of conidial fungus, *Tuberculariа coccicola*, which was found on scale insects, *Lepidosaphes* and *Hemichionaspis*, in Porto Rico. Specimens have been kindly furnished by Stevenson, and they are, as far as can be determined, identical with a similar conidial fungus which occurs on scale insects in Ceylon and India. In the two latter countries, however, the perithecial stage has been found, and this, as might be expected, is another species of *Nectria*, which will be named *Nectria Tuberculariae*.

Another undescribed species of *Nectria* has been found on *Mytilaspis* on *Citrus* in Ceylon. This will be described as *Nectria barbata*. Its conidial stage is unknown.

Historical sequence has been discarded in this account, in order to bring together the recorded species of the same genus. We must now go back to 1886, when Ellis and Everhart** described a species, parasitic on scale insects on orange trees in Florida, as *Ophionectria coccicola*. Ellis and Everhart dealt with the perithecial stage only; Zimmermann††, who found the same species on *Parlatoria* in Java, supplied a description of the conidial stage in 1901. This conidial form is a very curious production. It consists of a short parenchymatous column, surmounted by a white, usually conical, head of conidia. The conidiophores are short moniliform chains of a few cells. At the apex, each conidiophore bears a cluster of two to five, long, lanceolate conidia, which falls off as a whole. The detached conidium is compound, and consists of a basal cell, the apical

* Bull. Agric. Alger et Tunisie, 1907, p. 32.
† Bull. Soc. Myc. France, XXVIII (1912), p. 142.
‡ Ann. Myc., VII (1909), p. 437. § Grevillea, XVI (1888), p. 4.
‖ Vegetable Wasps and Plant Worms, 1892.
¶ Annual Rep., Insular Exp. Sta., Porto Rico for 1917.
** Journ. Myc., II (1886), p. 39; *ibid.*, p. 137.
†† Centralb. f. Bakt., Abt. 2, VII (1901), p. 872.

cell of the conidiophore, from which arise from two to five long, lanceolate arms. There are usually three arms, and the whole conidium resembles the print of a bird's foot. It has been stated that the arms close up when the conidium dries, and expand again when it is wetted, so that the spore is propelled along the surface of a leaf, but I have not been able to observe that effect.

In 1902, Hennings* found a similar conidial fungus on scale insects on orange from Brazil and instituted for it a new genus, with the species *Tetracrium Aurantii*. Later, von Höhnel† re-examined Henning's specimen and discovered perithecia on it, of the same structure as *Ophionectria coccicola*. But he placed his species in the genus *Puttemansia* and transferred Ellis and Everhart's species to the same genus.

In 1910, Massee‡ described a scale insect fungus from Trinidad as *Scleroderris gigaspora*. No type specimen is available, but it is agreed that this was *Ophionectria coccicola*.

In 1913, Miyabe and Sawada§ described *Ophionectria tetraspora* on *Parlatoria* from Formosa. I have examined a specimen of this from Formosa, and it appears to me to agree with von Höhnel's description of *Puttemansia Aurantii*, but I have not seen the type of the latter.

A third species, co-generic with *Ophionectria coccicola*, has recently been found in Ceylon.

Puttemansia Aurantii is at present known only from Brazil and Formosa. *Ophionectria coccicola* is a widely distributed species, and I have seen specimens from Ceylon, Formosa, South Africa, Florida, and Dominica (W.I.), while it has been recorded correctly from Java. These species have occurred on scale insects belonging to the genera *Parlatoria*, *Aspidiotus*, and *Lepidosaphes* (*Mytilaspis*).

Ellis and Everhart placed their species in *Ophionectria*. Seaver transferred it to a recently-instituted genus, *Scoleconectria*‖. Von Höhnel considers that it belongs to *Puttemansia*, which is a genus founded by Hennings for a fungus he thought was a Discomycete. Consequently the nomenclature question has become somewhat complicated. It will be discussed fully in a later paper. But the three species of *Ophionectria*, *Scoleconectria*, or *Puttemansia* which are parasitic on scale insects agree with one another in having a *Tetracrium* conidial stage. Consequently, as far as these species are concerned, the simplest way of escape from the maze of nomenclature is to institute

* Hedwigia, XLI (1902), p. 116.
† Fragmente zur Mykologie, XIII (1911), pp. 27–30.
‡ Kew Bulletin, 1910, p. 3.
§ Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, V (1913), p. 85.
‖ Mycologia, I (1909), p. 198.

for them a new genus characterised by the possession of multiseptate ascospores and a *Tetracrium* conidial stage. It may be objected that genera of ascigerous fungi should not be founded on conidial characters, but we have a parallel case in *Sphaerostilbe*, which is merely a *Nectria* with a Stilboid conidial stage. For this new genus, I propose the name *Podonectria*, the species being *Podonectria coccicola* (E. and E.), *Podonectria Aurantii* (v. H.), and *Podonectria echinata*.

Zimmermann*, in his paper on scale insect fungi found in Java (1901), described *Lisea Parlatoriae* on *Parlatoria*, and *Broomella Ichnaspidis* on *Ichnaspis*. I have not met with any species of either of these genera on scale insects. From Zimmermann's description and figure, it is clear that the second of these is not a *Broomella*.

Among the fungi so excellently figured by the Tulasnes†, there is one, *Melanospora parasitica*, the nature of whose parasitism is doubtful. It is generally supposed to be parasitic on entomogenous fungi, and has been recorded on *Isaria*, on *Botrytis Bassiana*, and on *Cordyceps militaris*. But the Tulasnes figure it growing on a cockchafer, and it has been recorded as parasitic on *Lecanium hemisphaericum* in India‡. It has been found on *Icerya Purchasi* in Ceylon; in the latter country, it often occurs with *Cephalosporium*, but in several cases it appears to have attacked the insect independently of any other fungus.

In the genera, which are more usually associated with insects, viz. *Cordyceps* and *Torrubiella*, the number of species recorded as occurring on scale insects is comparatively small. In *Torrubiella* there are four species: *Torrubiella rubra* Pat. and Lagh.§, from Ecuador (1893), *Torrubiella luteorostrata* Zimm.*, from Java (1901), *Torrubiella brunnea* v. Keissl.‖, from Samoa (1909), and *Torrubiella Lecanii* Johnston¶ from Cuba (1918). In the case of the first three the species of scale insect is not recorded. Two species have been collected in Ceylon, on *Aleyrodes*, and Parkin** recorded a gathering on *Aspidiotus*. This genus has not yet been revised.

In the case of the genus *Cordyceps*, three species are said to occur on scale insects, but very little is known about two of them. In 1861, Berkeley and Broome described *Cordyceps pistillariaeformis*††, growing on a scale insect, apparently a *Lecanium*, on Wych Elm at Batheaston. Apparently only two

* Centralb. f. Bakt., Abt. 2, VII (1901), p. 872.
† Selecta Fungorum Carpologia. ‡ Ann. Myc., IX (1911), p. 392.
§ Bull. Soc. Myc. France, IX (1893), p. 154.
‖ Micromycetes in Bot. u. Zool. Ergebnisse, Samoa Inseln, von Karl Rechinger.
¶ Mem. Soc. Cubana Hist. Nat. "Felipe Poey," III (1918), p. 80.
** Ann. R.B.G. Peradeniya, III (1906), pp. 18, 19.
†† Ann. Mag. Nat. Hist., Ser. 3, VII (1861), p. 451.

specimens were found, one conidial, and the other perithecial, but immature. From the herbarium collections, this species does not appear to have been found again in Britain. Prior to that, in 1834, Schweinitz had described *Sphaeria clavulata* in his Synopsis of North American fungi*. In 1869, when Berkeley and Curtis enumerated the fungi of Cuba†, they listed *Sphaeria clavulata* as a *Xylaria*, adding the extra-Cuban localities, North America and Venezuela. Subsequently, Peck stated that Schweinitz' *Sphaeria clavulata* was a *Torrubia*‡, or, as we should now call it, a *Cordyceps*, and Ellis and Everhart§ state that it is quite certain that the *Cordyceps* distributed by Peck is the genuine *Sphaeria clavulata*. It has been collected in America on several occasions, and is parasitic on *Lecanium*. Cooke‖ considered that *Cordyceps pistillariaeformis* B. and Br. is identical with *Cordyceps clavulata* (Schw.) E. and E., and Massee, Ann. Bot. IX (1895), p. 22, agreed with him. That view is most probably correct, but one would wish for further material of the British species before coming to a final decision. The herbarium specimens show some differences, which may however prove to be intraspecific. Berkeley's specimen of *Xylaria clavulata* from Cuba is a very immature *Xylaria*, and has little resemblance to *Cordyceps clavulata*.

The other species of *Cordyceps*, said to occur on a scale insect, is *Cordyceps coccigena* (Tul.) Sacc.¶, described and figured by the Tulasnes. It was collected in New Guinea, and was said to be growing on a coccus. As in the case of so many collections of these entomogenous fungi it was immature. However, from the excellent illustration, one is led to doubt the statement that it was growing on a coccus. The insect is large for a scale insect, and the figure shows that the body consisted of at least two distinct segments. Two clavae, with depressed globose heads, arise from the foremost segment. Except that the anterior segment is covered with mycelium, the illustration is good for *Cordyceps dipterigena* B. and Br., and I would hazard the suggestion that *Cordyceps coccigena* really grew on a fly.

In the case of the species which have already been mentioned, there is usually no doubt that the fungus is growing on a scale insect. It does not obliterate the insect. It generally grows out from the insect and produces its conidiophores at the margin of the scale and its perithecia in the same position or on the top of the scale. In *Podonectria*, there is a byssoid stroma

* Trans. American Philos. Soc., IV (1834), pp. 141–316.
† Journ. Linn. Soc., X (1869), p. 380.
‡ 28th Rep. New York State Museum.
§ North American Pyrenomycetes.
‖ Vegetable Wasps and Plant Worms, 1892.
¶ Selecta Fungorum Carpologia, III, p. 19, Tab. I, fig. 10.

which may spread over several scales, and in *Torrubiella* a similar stroma may cover the greater part of a colony of insects, but the scales are usually clearly evident. In the largest group of scale insect fungi, however, conditions are different; in it, each individual fungus grows over a single insect, and, as a rule, not only hides it completely, but consumes the whole of it, so that there is no trace of the insect left within the stroma. Therefore, it is not surprising that the first fungi recorded as parasitic on scale insects belonged to the *Sphaerostilbe* or *Nectria* group, while the species of the larger group, *Hypocrella* and *Aschersonia*, were described without reference to any host, except the plants on which they occurred.

The genus *Aschersonia* was founded by Montagne* in 1848 for two species, supposed to be phyllogenous, one from Guiana and the other from Tahiti. They were pycnidial fungi, brightly coloured, and evidently allied to the *Hypocreaceae*. In 1884, Saccardo† enumerated nine species; by the year 1900, the number had increased to 26; and at the end of 1919, there were 60.

It was not discovered that species of *Aschersonia* were entomogenous until 1894, when Webber‡, who had studied the fungi and insects which occurred on *Citrus* in Florida, demonstrated that *Aschersonia aleyrodis* was parasitic on *Aleyrodes citri* R. and H., *Aschersonia turbinata* on *Ceroplastes floridensis*, and, judging from his figures, *Aschersonia cubensis* on *Lecanium hesperidum* L. Webber suggested that all species of *Aschersonia* would be found to be entomogenous, but his results did not have any immediate influence on systematic mycology. Hennings§ described five species of *Aschersonia* from Java in 1902, and called attention to the remarkable phenomenon that these fungi generally occurred with various species of *Lecanium*, to which they bore so great a resemblance in form and colour that he considered the association should be regarded as a case of mimicry. Parkin‖, in 1906, supported Webber's view, and recorded eight gatherings of *Aschersonia* parasitic on *Aleyrodes* and seven gatherings on *Lecanium*; from the specimens left by him, these included *Aschersonia placenta*, *Aschersonia confluens*, *Aschersonia hypocreoidea*, and *Aschersonia samoensis*, on *Aleyrodes*, and *Aschersonia Coffeae* and *Aschersonia marginata* on *Lecanium*. Since 1904, new species of *Aschersonia* have generally been described as occurring on scale insects or *Aleyrodidae*; and at the present time, all species which are true *Aschersonia* in structure are known to be entomogenous.

* Ann. Sci. Nat., Ser. 3, x, p. 122. † Sylloge Fungorum, III, p. 619.
‡ U.S.A. Dept. Agric., Div. Veg. Physiol. and Pathol., Bull. 13 (1897).
§ Hedwigia, XLI (1902), pp. 145, 146. ‖ *Op. cit., supra.*

Species of *Sphaerostilbe* and *Nectria* attack *Lepidosaphes* (*Mytilaspis*), *Chionaspis*, *Aspidiotus*, *Fiorinia*, and allied insects. Species of *Aschersonia*, on the other hand, attack only insects belonging to the families *Lecaniidae* and *Aleyrodidae*. Moreover, there is a notable difference between the species parasitic on the two families respectively: those parasitic on *Aleyrodidae* have paraphyses in the pycnidium, while those parasitic on *Lecaniidae* have no paraphyses. It is curious that of Montagne's two species, *Aschersonia taitensis* is aleyrodiicolous, while *Aschersonia guianensis* is lecaniicolous.

The perithecial stage of *Aschersonia* is *Hypocrella*, and as might be expected, it also is entomogenous. The earlier mycologists included species of *Hypocrella* in *Hypocrea*, from which it differs in having long filiform spores which divide into rod-shaped, or oval, part-spores in the ascus. *Hypocrella* was split off in 1878 by Saccardo*, who placed in it four species, only one of which, the type species, now remains in the genus. Ten species were enumerated by Saccardo† in 1883, but the number described up to the end of 1919 is seventy (including *Fleischeria* and *Moelleriella*).

In general, species of *Hypocrella* so closely resemble the corresponding species of *Aschersonia* that it is not possible to decide which a given stroma is without sectioning it. Yet it was apparently not until 1896 that any relationship between the two was suggested. In that year, Massee‡ stated that he had examined Berkeley's specimen of *Aschersonia oxyspora* and found that it was a *Hypocrella*, Berkeley having mistaken the part spores for *Aschersonia* spores. He had also examined part of Montagne's type of *Aschersonia taitensis*, the type species of the genus, and had found that the young stromata were covered with a dense stratum of fusiform spores while "the primordia of perithecia were very evident in the substance of the stroma." Hence he suggested that "in all probability the genus *Aschersonia* will prove to be nothing more than the conidial form of *Hypocrella*."

I have not been able to trace any further observations on this point by Massee, but three years later, in his Textbook of Plant Diseases (1899), he wrote, "I have shown that species of *Aschersonia*, which hitherto were only known to produce a conidial form of reproduction on living leaves, produce an ascigerous form of fruit, following the conidial stage, on fallen dead leaves."

Massee's hypothesis, that *Aschersonia* is the pycnidial stage of *Hypocrella*, is undoubtedly true, but the observations which

* Michelia, I, p. 322.
† Sylloge Fungorum, II, p. 579.
‡ Journ. of Botany (1896), p. 151.

he cited in support of it are not correct. *Aschersonia oxyspora* Berk. is an *Aschersonia*, and its *Hypocrella* stage was unknown until recently collected in Ceylon. In *Aschersonia taitensis*, the stromata are not covered with spores; they bear discontinuous spore masses which have oozed out of the pycnidia, and the supposed primordia of the perithecia are the pycnidia in which they were produced. Moreover, no case is known in which the pycnidial form is followed by the development of an ascigerous form on dead fallen leaves. When the leaf falls, the fungus decays.

In general, an *Aschersonia* stroma does not subsequently become perithecial. Exceptions to that rule may be found in *Aschersonia turbinata* and *Aschersonia placenta*. But effete *Aschersonia* stromata usually decay, even when on living leaves, or stems. In some gatherings, all the stromata will be *Aschersonia*, in others all *Hypocrella*, and it has not yet been possible to determine what conditions govern the production of either stage. Just as, in *Sphaerostilbe*, the *Microcera* stage is commoner than the *Nectria* stage, so the *Aschersonia* stage is much more frequent than the *Hypocrella* stage.

How, then, is it possible to correlate species of *Aschersonia* with their *Hypocrella* stages? Simply by finding, as Massee thought he had, both stages in the same stroma. Instances do occur in which a stroma is, at the same time, pycnidial and perithecial, and one has to wait until they turn up.

The first definite proof of Massee's theory was provided by Möller*, who found both stages in the same stroma in *Hypocrella cavernosa*. Möller also observed that *Aschersonia basicystis* was similar in shape, etc., to *Hypocrella phyllogena*, and recorded that Lindau had found both stages in the same stroma in specimens sent him from Brazil. Zimmermann† described both stages in *Hypocrella Raciborskii*, and Thaxter‡ has found both in *Hypocrella turbinata*, while during a recent revision of these two genera, both stages have been found in the same stroma in the case of eleven other species.

As I have already stated, 70 species of *Hypocrella* and 60 species of *Aschersonia* have been described. In revising these genera, it has been necessary to make seven new species and to transfer four from other genera. Nevertheless, the total number of valid names is only 54, covering 42 species. In the group parasitic on *Lecanium*, there are at present, 20 species of *Hypocrella*; the corresponding *Aschersonia* is known in eleven cases, and in six of these it has received a name. In the group parasitic on *Aleyrodes*, there are nine species of *Hypocrella*; the

* Phycomyceten und Ascomyceten, 1901.
† *Op. cit., supra.*
‡ Botanical Gazette, LVII, pp. 308–313.

Aschersonia stage of each of these is known, and in six cases it has been named, while there are in addition 13 unattached Aschersonias.

Hypocrella and *Aschersonia* occur on living leaves and stems, on which they form superficial, easily detached stromata. The stromata are usually brightly coloured—white, yellow, red, or brown—and may be subglobose, hemispherical, flattened pulvinate, or scutate. As a rule, they do not exceed 3 mm. in diameter, but one giant from Brazil, *Hypocrella Gartneriana*, is said to attain a diameter of 3 cm. The stroma is composed of thick-walled hyphae and in the species parasitic on *Lecanium* it is usually very hard and sclerotioid. Penzig and Saccardo* instituted the genus *Fleischeria* for the harder species of *Hypocrella*, and, while it is scarcely possible to consider hardness a generic distinction, the name can be associated with a morphological character, as it was applied to a *Hypocrella*, whose *Aschersonia* stage has no paraphyses, whereas in the type species of the genus *Hypocrella*, the *Aschersonia* stage has paraphyses. This sclerotioid character is no doubt to be correlated with the fact that these fungi are superficial, and, not being able to obtain water from the leaf, must be able to withstand periods of drought. It is shared by several other fungi in the tropics which overrun leaves and twigs: the common Thread Blights, for example—white, normal-looking mycelia which occur on the upper parts of bushes and trees—are composed chiefly of sclerotioid hyphae.

One peculiar species, *Hypocrella scutata*, which has been found in Singapore and the Philippines, has a stroma composed chiefly of resin in which the hyphae are embedded. It breaks with a vitreous fracture, and if a lighted match is applied to it it burns like resin. Failing any other explanation, one is led to assume that this peculiarity is due to the insect on which it is parasitic, but it has not been possible to verify that assumption.

In all the collections of *Hypocrella* and *Aschersonia* which I have examined, whenever it has been possible to identify the insect, the latter has belonged to the *Lecaniidae* or to the *Aleyrodidae*. *Aschersonia Coffeae* has been recorded† as occurring on *Aspidiotus*, and *Aschersonia marginata* on *Parlatoria*, but these records are probably erroneous. It is necessary to exercise great caution in deciding what insect a *Hypocrella* is parasitic upon. If a *Lecanium* and a *Lepidosaphes* occur together on the same leaf, a lecaniicolous *Hypocrella* may destroy all the individuals of the *Lecanium*, leaving only the *Lepidosaphes*.

Another ascigerous genus, which occurs on scale insects

* Malpighia (1901), p. 230.

† Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, v (1913), pp. 73–90.

throughout the tropics, forms black, irregular stromata over or at the side of the scale, and often extending some distance from it. This is *Myriangium*. The stroma is parenchymatous, without true perithecia, but with asci embedded singly in the tissue. The spores are muriform. It was first recorded on scale insects by Zimmermann* in Java in 1901, and has since been found on them in Ceylon, Florida, the West Indies, etc. Some doubt has been expressed concerning the parasitism of this group, because it frequently occurs in company with *Sphaerostilbe*, but the explanation of that would appear to be that it attacks the same species of scale insects as the latter. In many instances it is the only fungus present.

Mr Ramsbottom has pointed out to me that *Myriangium* has been known to be a British genus for more than half a century, though it has not been included in lists or textbooks of British fungi. When Berkeley described the genus†, he stated that it was allied to *Collema*; hence it was at first included among the lichens. Subsequently, it was discarded by the lichenologists, and the mycologists omitted to take it up. Specimens of *Myriangium* were collected in abundance during the Foray on *Chionaspis salicis* on Ash, and effete stromata have been gathered on the same host in Norfolk and Yorkshire.

It is customary to refer the species of *Myriangium* found on scale insects to *Myriangium Duriaei* Mont. and Berk., the type species of the genus, originally recorded in 1845 from the Pyrenees, Algeria and Australia, but the examination of the numerous gatherings of this genus now available has not yet been completed. *Myriangium Acaciae* McAlp. is entomogenous.

Myriangium is generally placed in the *Plectascineae*, in the subfamily *Myriangiaceae*. Von Höhnel‡, who has recently revised the subfamily, considers that the latter should be placed in the *Dothideales*. *Myriangiaceae* has been a convenient centre for little-known genera of doubtful affinities, and von Höhnel has found it necessary to reduce the 23 genera hitherto included in it to five, either by synonymy or exclusion. Apparently 12 species now remain in *Myriangium*. It remains to be determined how many of these are valid, how many are entomogenous, and whether any of the other genera of *Myriangiaceae* which have superficial stromata are entomogenous.

As recorded by Parkin§, a black stromatic fungus, somewhat resembling *Myriangium*, but pycnidial, is found on *Mytilaspis* in Ceylon. It usually has prominent pycnidia, which contain small, brown, narrow-oval spores. Parkin suggested that this

* *Op. cit., supra.* † Hooker's Lond. Journ. Bot., IV (1845), p. 74.
‡ Fragmente zur Mykologie, VI Mitt. (1909), pp. 75–102.
§ *Op. cit., supra.*

is a pycnidial stage of *Myriangium*, but that has not yet been verified.

No species of the *Entomophthoreae* was known on scale insects prior to 1918, when an *Empusa*, *Empusa Lecanii*, was recorded* on scale insects on coffee in Mysore.

The list of families which are known to provide entomogenous fungi was extended by a remarkable addition in 1907, when von Höhnel† announced his discovery of scale insects beneath the stroma of a *Septobasidium*. That has since been repeated‡ in Ceylon (where all the known species of *Septobasidium* appear to be entomogenous), in Japan, and on specimens from India and Canada.

Species of *Septobasidium* are common in the tropics, where they occur on the stems, and sometimes on the leaves, of living plants, without, as a rule, causing any apparent injury. The commoner species have a peculiar structure. They first cover the stem with a thin adherent stroma, from which arise numerous erect bristles or fascicles of hyphae. Another continuous layer is then developed over the tops of the bristles, so that the structure is two-storied, the upper storey being supported on pillars. The hymenium is developed on the surface of the upper layer. If the fungus is examined in an early stage of development, the remains of the scale insects will be found beneath the initial layer of the stroma. The fungus grows over and kills whole colonies of scale insects, and completely covers the stems of the host plant.

In Ceylon, *Septobasidium rameale* (Berk.) Bres. is frequent on orange trees infested with *Mytilaspis*, sometimes clothing all the stems for a length of several feet and spreading from them over the leaves. A species, allied to *Septobasidium pedicellatum* (Schw.), attacks scale insects on tea, and in some cases covers all the stems of a tea bush. Another species which is found on tea is usually associated with *Chionaspis*. The tea planter is often alarmed when he finds these fungi covering his bushes, but, in general, they are harmless. There are, however, exceptions to the rule. Some species, after destroying the scale insects, attack the plant. That happens in the case of an undetermined species on tea in Ceylon, the species which causes the disease known as Velvet Blight on tea in Northern India, and several species on tea and mulberry in Japan§.

Several species of Hyphomycetes have been recorded as parasitic on scale insects. One of the most interesting of these is a

* Dept. Agric. Mysore, Ento. Series, Bull. 4.

† Sitzungsber. d. Kais. Akad. d. Wissensch. Wien, Math. Naturw. Kl., CXVI (1907), p. 740.

‡ Annals of Botany, XXV (1911), p. 843.

§ Mycologia, X (1918), pp. 88–90.

Fusarium, which was originally described as parasitic on *Aspidiotus Aurantii* in Australia by McAlpine* in 1899 under the name of *Fusarium epicoccum*. Its conidia are variable, sometimes nearly straight, sometimes hook-shaped, but the typical conidium is stout, short, three-septate, and curved to two-thirds of a circle. It was named *Microcera Parlatoriae* by Trabut† in 1907 from specimens on *Parlatoria* on orange in Algeria, *Microcera curta* by Saccardo‡ in 1909 from specimens on a scale insect on *Tilia* in Germany, *Microcera Tonduzii* by Patouillard§ in 1912, from specimens on *Ficus* from Costa Rica, and *Fusarium Aspidioti* by Sawada‖ in 1914 from specimens on *Aspidiotus* on *Pyrus* in Japan. The interesting point about this *Fusarium* is that the short, curved conidium exactly resembles one of the forms of conidia described by Berkeley and Broome as part of *Sphaerostilbe aurantiicola*. It occurs quite commonly with *Sphaerostilbe aurantiicola* in Ceylon, but I have never been able to detect the sporodochium in any of my numerous gatherings of that species. One mounts the ordinary *Microcera* synnema, or an isolated perithecium, and finds the small curved conidium on the slide. It apparently occurs on the slight weft of mycelium at the base of the perithecium. It is abundant in the perithecial specimens collected at Florence in 1860. I was formerly inclined to regard this conidium as typical of *Sphaerostilbe aurantiicola*, but I have found it a specimen of *Sphaerostilbe flammea* from Georgia, Ravenel 3376. The question then arises whether *Fusarium epicoccum* is a stage of *Sphaerostilbe*, or whether the conidia found with the *Sphaerostilbe* are intrusive. Against the first theory, there is the fact that all the collections of the *Fusarium*, with one exception, contain only the *Fusarium*, and the exception is such a mixture that nothing can be deduced from it, as it includes *Sphaerostilbe*, *Pseudomicrocera*, and *Podonectria* on the same leaf. Against the second, we have the absence of any gathering of the *Fusarium* sporodochium from Ceylon.

Another *Fusarium*, *Fusarium coccidicola*, was described by Hennings¶ in 1903 from specimens on tea collected in German East Africa. I have not seen the type, but from the description it would appear to be *Pseudomicrocera*.

A Hyphomycete, which is of considerable economic importance in the Eastern Tropics, was described by Zimmermann** in 1898

* Fungus diseases of Citrus trees in Australia, 1899.
† Bull. Agric. Alger et Tunisie, 1907, p. 32.
‡ Ann. Myc. VII (1909), p. 437.
§ Bull. Soc. Myc. France, XXVIII (1912), p. 142.
‖ Bot. Mag., Tokyo, XXVIII (1914), p. 312.
¶ Engler's Bot. Jahrb. (1903), p. 57.
** Over eene Schimmelepidemic der groene Luizen, Buitenzorg, 1898.

as *Cephalosporium Lecanii*. It is known to occur in Java, Ceylon, and India. In Ceylon, it has been found on several species of *Lecanium*, but it is especially common on *Lecanium viride*, the common scale insect pest of coffee. Indeed, during the rainy seasons, *Lecanium viride* appears to be invariably attacked by this fungus. Recently, it has been found to attack *Icerya Purchasi* in Ceylon, and up to the present it appears to have effectively controlled that insect.

Similarly, *Hyalopus Yvonis* Dop (1905) is said* to have controlled an *Aspidiotus* which was causing great damage to coco-nut palms in Martinique. As *Hyalopus* is not very different from *Cephalosporium*, this species needs comparison with *Cephalosporium Lecanii*.

Other Hyphomycetes which have been found on scale insects are *Acrostalagmus coccidicola* Guéguen (1904) on a coccus on a shrub at the Paris Exhibition of 1900; *Geotrichum coccophilum* Speg., on a coccus on *Cycas revoluta*, Brazil; *Acremonium araucanum* Speg., on *Aspidiotus*, Chili; *Stilbum coccophilum* Sacc., and *Penicillium coccophilum* Sacc., on *Ceroplastes* in the Botanic Garden, Palermo; *Sporotrichum Lecanii* Peck, on *Lecanium* in North America; *Sporotrichum globuliferum* Speg., on *Lecanium hesperidum* at Lisbon†; *Verticillium heterocladum* Penz., on *Lecanium hesperidum* on orange, in Italy. This group has not been critically examined.

In addition to the identifiable fungi enumerated, a number of sterile stromata occur on scale insects. Some of these appear to belong to *Septobasidium*. A small purple red lenticular stroma, which is common in the Eastern Tropics, apparently belongs to *Torrubiella*. Others seem to belong to *Aschersonia*. There is some evidence that these stromata are sterile because they have been attacked by another fungus, e.g. *Cladosporium*, but this phase of the subject is still under investigation. The brown sterile fungus found on scale insects in Florida has been found to be an *Aegerita*, *Aegerita Webberi*; according to the specimens submitted to me, it is not a state of a *Meliola*.

All the fungi which have been mentioned ultimately make their appearance on the exterior of the scale insects attacked. There is however another class of fungi which are entoparasites. The first of these to be discovered was observed by Leydig in *Lecanium hemisphaericum* in 1854, but their nature was not recognised until 1887 when Monier‡ described *Lecaniascus polymorphus*, parasitic on *Lecanium hesperidum*. During the current century, considerable attention has been given to this group,

* Bull. Scient. France et Belgique, XXXIX (1905), p. 135.

† Camara Pestana, J., Bull. Soc. Portugaise Sci. Nat. Lisbonne, II (1908), pp. 14–18.

‡ Bull. Soc. Zool. France, XII (1887), pp. 150–152.

and about ten species have been described*, parasitic on *Lecanium*, *Pulvinaria*, *Aspidiotus*, *Chermes*, *Physokermes*, *Aleurodes*, *Icerya* and *Dactylopius*. The majority of these belong to the Saccharomycetes. This group is one which invites the attention of British mycologists, as all the existing records have been made in temperate countries—France, Italy, Bohemia, and Germany.

The list of fungi which are parasitic on scale insects is already a long one, but there is every probability that it will be still further extended. The majority of the species are essentially tropical, and when more is known about the biology of tropical fungi, new forms may be expected to be added. From the specimens available in herbaria, these fungi would be considered rare, but it is generally possible, at least in Ceylon, to collect them in large numbers by searching specially for them. I have seen a tree of the Ceylon Patna Oak (*Schleichera trijuga*), on which nearly every leaf bore *Aschersonia placenta*, in some cases so crowded that the stromata had fused into a continuous sheet. The discovery of a single *Aschersonia* usually leads to the collection of dozens, or sometimes hundreds, if the bush is systematically examined, though of course disappointments do occur.

No one who has collected these fungi in the tropics can fail to be impressed by the enormous destruction of scale insects which they bring about. A *Septobasidium* will wipe out all the insects on a badly-infested orange tree or tea bush. *Cephalosporium Lecanii* will attack *Lecanium viride* on coffee over the whole of an estate. I have spent a morning in a Ceylon jungle which consisted almost entirely of Ebony trees, collecting *Aschersonia placenta* on the Ebony leaves, and have not been able to find a single specimen of the Aleyrodid on which it grew: the insect had been obliterated over an area of several acres. Again, in the jungle above Hakgala, *Aschersonia oxystoma* is common on the shrub, *Sarcococca pruniformis*, but although I have collected it there periodically for several years, I have not been able to determine what scale it is parasitic on. When a scale insect on a particular tree is attacked by a fungus, its destruction is so complete that one wonders how the species manages to survive.

Under such circumstances, it is not surprising that attempts have been made to control the scale insect pests of economic plants by means of entomogenous fungi. The best known of these, in fact the only attempts which have been conducted on an experimental basis, have been carried out in Florida, where, since about 1896, the use of *Aschersonia Aleyrodis* and

* See Buchner, Arch. Protistenk. xxvi (1912), pp. 1–116.

Aschersonia Goldiana has been recommended for the control of *Aleyrodes*, and *Sphaerostilbe, Pseudomicrocera*, and *Podonectria* for the control of *Aspidiotus, Lepidosaphes*, etc. For several years, these were regarded as the sole instances of successful control of insects by the use of entomogenous fungi, though adverse criticism was not lacking. Finally, the United States Bureau of Entomology undertook a special investigation into the subject, and the results of four years enquiry and experiment have been published by Messrs Morrill and Back* in a Bulletin entitled, "Natural Control of White Flies in Florida," from which the following extracts are quoted.

"Much damage has resulted in the past from ill-advised attempts to check the spread of white flies in newly infested localities by means of fungus parasites. The control of destructive diseases affecting citrus trees has been interfered with by (these) fungus parasites and much preventable loss thereby incurred. This interference is due to the fear that the fungicides recommended for the diseases referred to, would, if applied to the trees, check the white fly fungus parasites with injurious results.

"Under natural conditions, without artificial assistance in spreading, the fungi have ordinarily in favoured localities, controlled the white fly to the extent of about one-third of a complete remedy through a series of years.

"The most successful method so far devised for introducing the red and yellow Aschersonias into groves where they do not occur is the spore spraying method, first successfully employed and recommended by Dr E. W. Berger. For the introduction of the brown fungus the brushing or dipping and the rubbing methods first used by the authors are as successful as any yet discovered, but are not so reliable as the spore spraying methods for the Aschersonias. The infections secured by artificial means of introducing fungi, while successful in introducing the fungi, have thus far proved of little or no avail in increasing their efficacy after they have once become generally established in a grove. Experiments by the authors, and by citrus growers in co-operation with the authors, involving the treatment of thousands of trees with suitable 'checks' or 'controls' have shown that when fungus (red or yellow *Aschersonia*) even in small quantities is present in a grove there is no certainty that from three to six applications of fungus spores in water solution will result in an increased abundance of the infection on the treated blocks of trees by the end of the season. In some of the most important and carefully planned and executed experiments the fungus has increased more rapidly in sections of

* U.S. Dept. of Agric., Bureau of Entomology, No. 102.

the groves which were not sprayed with spore solutions than in the experimental blocks. In no case has practical benefit been observed to result from efforts to increase the efficiency of the fungi in groves where they previously occurred. The above remarks apply especially to the Aschersonias. With the brown fungus, efforts to increase the efficacy have been equally disappointing from a practical standpoint.

"As a result of the investigations reported herein and of observations and experience covering a period of four years the authors conclude that there are at present no elements of natural control herein dealt with which can be relied upon to give satisfactory results. Under present conditions it is unquestionably more profitable to depend upon artificial remedies."

The Florida results thus agree with those of other experiments of the same character, and at the present day after 30 years' trial there is no instance of the successful control of any insect by means of fungus parasites. If the entomogenous fungi already exist in a given area, practically no artificial method of increasing their efficacy is possible. If they are not present, good may result from their introduction, if local conditions are favourable to their growth, but, on the other hand, their absence would appear to indicate unfavourable conditions.

It would seem that a fungus makes little progress until the insects are excessively numerous, either locally or generally, when for reasons not known an epidemic of fungus disease breaks out. And in this connection it may be noted that the apparently successful experiments in inducing a more rapid dissemination of an entomogenous fungus have usually been made during such an epidemic.

Morrill and Back's statement that *Aschersonia Aleyrodis*, etc., have controlled the white fly to the extent of about one-third of a complete remedy is apparently to be interpreted that an epidemic of fungus disease among the scale insects occurs every three years. Where an insect is always present, these epidemics appear to occur at definite intervals; and where the occurrence of the insect is discontinuous, they appear to occur at a definite period from the first appearance of the insect. The Wilt disease of the Tea Tortrix of Ceylon (*Homona coffearia*), though not a fungus disease, gives a notable illustration of that. The occurrence of that insect as a pest is discontinuous. In the first year of its appearance in any locality, the insect increases without any check; in the second year, Wilt disease attacks a small proportion of the caterpillars; in the third year, it practically kills out every one. In the case of *Cephalosporium Lecanii* on *Lecanium viride* on coffee in Ceylon, an epidemic of fungus disease occurs in the same locality during each rainy season;

in that case the controlling factor is probably climatic. On the other hand, in a small plantation of mulberry trees at Peradeniya, it is always possible to find *Sphaerostilbe aurantiicola* in the rainy season, but only on a few trees, though a large number of trees may be attacked by the same scale insect; in that case, some other than climatic factors must be involved.

The problem which has yet to be solved by those who wish to control insects by means of fungi is how to create an epidemic at a time when such an epidemic would not occur naturally. The evidence indicates that it is not possible to accomplish that by the mere introduction of the fungus or by spraying spores from natural or artificial cultures. The solution of the problem probably depends in each case upon a study of the bionomics of the insect, and it is satisfactory to note that the United States Department of Agriculture has appointed a Myco-entomologist specially to investigate these diseases of insects.

I should like to make my position on this point clear. I do not for one moment wish to deny that it may be possible ultimately to discover what factors govern the incidence of these diseases of insects, and that, in consequence of such discovery, it may be possible to utilise them to control insect pests. But I do hold that, in the present state of our knowledge, after nearly thirty years of investigation and experiment, there are no facts which would warrant the recommendation of any such means of control.

Though the majority of the scale insect fungi are tropical, there is some work to be done on them in the British Isles. We require more material of *Cordyceps pistillariaeformis*, which has occurred on a *Lecanium* on elm. *Sphaerostilbe flammea* is apparently rare in Britain, but it should be sought for in the winter on *Chionaspis salicis* on willow and ash. The insect is especially abundant on ash, coppiced ash in hedge rows being generally badly infested. *Fusarium epicoccum*, not yet recorded as British, should be found in the same situation, and it might be possible to determine its perithecial stage. A *Verticillium* has recently been collected on the same host in Yorkshire; it forms a delicate white mould over the colony of scale insects.

With the exception of the *Cordyceps*, all the scale insect fungi found in Britain have occurred on *Chionaspis*. In the tropics, *Aspidiotus* and *Lepidosaphes* are the favourite hosts of the *Nectria* group, and it should be possible to find species on the common scale insects of fruit trees in Britain, if search is made for them in the winter.

THE SPORULATION OF GONIDIA IN THE THALLUS OF EVERNIA PRUNASTRI ACH.

With Plate I.

By Robert Paulson, F.L.S.

Evernia prunastri, one of the most widely distributed of the British fruticose lichens, occurs frequently, sometimes abundantly, on trunks and branches of trees in woodlands and hedgerows; less often on rocks, walls, palings and bare sandy soil. Its much branched flaccid thallus is decumbent or pendulous in habit except in the early stages of growth when it is more or less erect. A form *retusa*, recorded from a small number of localities, consists solely of dense tufts of erect fronds (11). In colour it is grey-green above and paler or whitish beneath. The branches are compressed and are frequently white-sorediate at the margin, the broader, older ones, being reticulate on the upper surface and finely, longitudinally channelled below. They terminate in two flattened points, which, after a period of further growth, fork again in a similar manner and thus exhibit the characteristic appearance of dichotomy. The apothecia, rarely produced, are large, sub-pedicellate and dark brown. They sometimes have a disc measuring as much as 12 mm. across; the margin is prominent and involute.

Before cutting the sections from which the preparations, to be described later, were made, small portions of the thallus were placed in a weak chromo-acetic fixing solution for at least twenty-four hours; a longer period does no harm. After thoroughly washing for two hours, the material was passed into paraffin wax in the ordinary way. Heidenhain's iron-alum-haematoxylin and Delafield's haematoxylin were the staining reagents employed. Permanent mounts were as a rule put up in Canada balsam, but these do not show the cell wall sufficiently defined for all purposes, so that when preparing gonidia in the various phases of division, it was found advisable to mount some sections in glycerine, by which method the newly formed cell wall of a daughter gonidium is rendered distinctly visible (fig. 2).

The portion of the thallus most favourable for obtaining large numbers of actively dividing gonidia is that part situated at from four to five millimetres below the apex of a young branch. In early spring, and in showery weather after a prolonged drought, numerous dividing gonidia can be found in all growing parts.

A transverse section of the thallus taken more than a centimetre from the end of a branch exhibits a dorsiventral structure consisting of the following differentiated layers, (*a*) upper cortical layer, (*b*) gonidial layer, (*c*) medulla, and (*d*) lower cortical layer, but a section across one of the extreme points of a branch shows an approach to a radial arrangement of the above.

The hyphae of the upper cortical layer are welded together so completely that their identity is almost entirely lost, but in the part adjoining the gonidial layer it is possible to trace the cut ends of the hyphae after treatment with potassium hydrate.

The gonidial layer consists of bright green spherical cells interspersed among hyphae that have moderately thin walls. A feature of this layer, especially when there is active growth, is that the gonidia are grouped in spherical masses (fig. 1), a condition that suggests the common origin of each set from a single mother cell. The gonidia composing a group are approximately of the same size, those of one group may have a diameter of three microns while those of another measure as much as ten microns across, but groups of intermediate sizes are always present.

The medullary layer extends through one-half of the thickness of the section; it consists of a loose meshwork of branched hyphae with few septa. The average width of a hypha is four microns.

The mature gonidium of *Evernia prunastri* is a spherical cell with a diameter of from 10 to 15 μ (fig. 3), except when it is subjected to the considerable pressure caused by the rapid multiplication of cells during the periods of active growth (fig. 1). The colourless cell-wall has a thickness of 1·5 μ. The addition of chlorzinc-iodine produces a blue-purple colour reaction but the walls of the hyphae that are present remain colourless. Each gonidium contains a single bright green parietal chloroplast, minutely irregular on the outer surface, surrounding a large central nucleus the diameter of which equals one-third that of the cell (fig. 2). The cytoplasm is finely reticulated; this may account for the statement by a recent writer that a network of hyphae, devoid of a cell wall, sometimes surrounds the chloroplast. One or more minute peripheral bodies stain deeply; they are always surrounded by a light area. The significance of these bodies we have not yet been able to ascertain.

Most writers regard the central body as a pyrenoid but a close examination of it has led to the conclusion that it is the nucleus, for when seen with critical illumination and a magnification of 1000 diameters it appears distinctly granular (7) and when removing superfluous stain (Heidenhain's iron-alum-haematoxylin), by means of the mordant, the colour is reduced

much more slowly in the central body than in the other cell contents. By the fuchsin and bichromate of potash method this body is rendered colourless by thoroughly washing with water after staining; a pyrenoid remains coloured. The central body has not the distinctly semi-crystalline outline so often figured in drawings of gonidia.

It has been generally assumed that the green gonidium of lichens, similar to that of *Evernia prunastri*, increases in number by means of a vegetative cell-division like that observed in the cells of *Protococcus viridis* Ag. (= *Pleurococcus* of most modern authors), viz. by the formation of a transverse wall, and that sporulation takes place only after the gonidium has been isolated from the lichen thallus and subjected to cultural methods similar to those described by Famintzin, and Baranetzky (5), Woronin (13), Bornet (2) and recently by Chodat (3).

The gonidium of *Evernia prunastri* is common to a large number of fruticose, foliose and crustose lichens belonging to the following genera. *Chaenotheca, Calicium, Cyphelium, Sphaerophorus, Candelaria, Parmelia, Cetraria, Evernia, Ramalina, Usnea, Alectoria, Thelochistes, Xanthoria, Placodium, Candelariella, Physcia, Rinodina, Lecanora, Acarospora, Lecania, Icmadophilus, Haematoma, Pertusaria, Gyrophora, Stereocaulon, Cladonia, Lecidea, Biatorella* and *Buellia.*

The gonidium does not multiply vegetatively as a constituent of the lichen thallus, but the original protoplast of the mother cell divides into two, four, eight or sixteen, sometimes more, distinctly separate wall-less masses (figs. 3 and 4). Each of these masses (reduced zoogonidia?) rapidly secretes a cell-wall, develops a chloroplast and nucleus and, in a short period, resembles exactly, in miniature, the mother cell as it appeared before it commenced to sporulate. The mother cell-wall, either by becoming diffluent or by bursting, sets free the daughter cells (fig. 5). May not the empty cells of Danilov (4) or the nekral layer of Elenkin be the empty cells after sporulation has been completed? In most cases the mother cell-wall becomes diffluent and the daughter cells are left together in a spherical group until hyphae force themselves between the daughter gonidia and push them farther apart (fig. 6), or, until they completely surround a group and bind the cells together into a mulberry-like mass.

It is probable that the most active period of sporulation in lowland districts is in the early months of the year, February to April, but sporulation has been found taking place at all periods of the year except during prolonged drought.

Sporulation of the gonidia of *E. prunastri* is exactly similar to that which takes place in *Chlorella vulgaris* Beijer. when

living in a free state. The photomicrograph, fig. 5, is very like that of the drawings by Grintzesco, which illustrate the paper on *Chlorella vulgaris*, with the exception that the chloroplast of the daughter cell in the drawings is decidedly clear at one spot (6). It is not so in the illustration in West, p. 194 (12). The latter adds in his description of the division of the free *Chlorella* cell "It is almost exactly like the formation of zoogonidia in so many of the *Protococcales* and it is not unlikely that the daughter cells are reduced zoogonidia." The same may be said of the formation of daughter gonidia within the lichen thallus.

Diagrams and drawings hitherto published for the purpose of illustrating a transverse section of a lichen thallus containing bright green gonidia convey the idea that the cells are at all periods approximately of the same size even when they are described as cells of *Protococcus* which divide vegetatively by the formation of a transverse wall along which segmentation takes place. The actual separation of the two daughter gonidia is not indicated. There are very few published drawings that suggest sporulation, and when such a suggestion does appear, as in two of the illustrations by Schwendener (9) no description of this condition of the cell is given. The statement is made that the cells are dividing and this has been interpreted as meaning in all cases, dividing vegetatively. The partition wall (eine zarte Scheidewand) is specially referred to. De Bary, 1884, 16 years after the publication of Schwendener's classical paper (8) says "The Fungus alone produces spores, the Alga with a few exceptions remains barren *as long as it is combined with the Fungus*." The only exception that de Bary notes is that of *Synalissa symphorea*, a lichen with a blue-green alga (1). This form of gonidium is not under discussion in the present paper.

The algae *Cystococcus* and *Protococcus* are described as the gonidia of lichens, the first by Schwendener (8) and the second by Bornet (2), but great uncertainty concerning the identity of these has arisen from the fact that in neither case is a detailed account given of the gonidium. The transverse partition of the gonidium, shown in a few of Schwendener's drawings, does resemble a vegetative division, and was regarded as such by the author (10), but in the light of our present knowledge the so-called transverse walls may be the first indication of the splitting up of the protoplast that occurs at the commencement of sporulation. In Pl. VIII, fig. 10 of Schwendener's paper (9) there is a gonidium showing three internal masses out of four that are present; they are similar in shape and arrangement to those now shown in the sporulating gonidium of *E. prunastri*, fig. 3. In both cases three of the tetrahedrally arranged masses

of the divided protoplast are clearly indicated, but in the latter case there is no cell-wall between the masses.

Bornet (2) in his illustrations of the synthetic building of the thallus of *Physcia* (*Xanthoria*) *parietina* from the germinating fungus spores of that lichen and the cells of *Protococcus* leaves one in doubt respecting the identity of the alga. On Pl. X, fig. 2 there are a few cells that indicate division by transverse walls; this suggests *Protococcus viridis* Ag. but great uncertainty on this point arises when it is known that the gonidium of *Physcia parietina* within the thallus, and when isolated, does not divide by a transverse wall but that sporulation takes place similar to that described respecting *E. prunastri*. The question must arise as to whether the alga used in the synthetic building of *Physcia parietina* was pure, in the modern sense of the word. When cutting sections of a lichen thallus a few cells dividing vegetatively are often present on the microscope slide; they are stray ones that have settled upon the upper surface together with fungus spores and other foreign matter. It is of great importance that the thallus should be thoroughly washed before commencing to cut sections for examination, for without this precaution erroneous conclusions will most probably be the result.

In a recent paper (7) it was suggested that the gonidium common to many lichens is a species of *Chlorella*, from the fact that the sporulation of the algal cells, within the thallus and also in those cells that have been isolated from it and subjected to cultural methods, is exactly similar to that which takes place in free *Chlorella* cells. The number of daughter cells produced in the green gonidium of the lichen thallus is usually eight or sixteen. In some free species of *Chlorella*, viz. *C. miniata* Kutz. the same numbers occur. Isolated gonidia, from the thallus of *Cladonia pyxidata*, cultivated on agar-glycose, produced as many as 32 daughter gonidia and in one case a zoospore appeared (No. 63 de la Collection Chodat (3)). Gonidia containing eight or sixteen daughter cells frequently occur within the thallus of *Cladonia pyxidata*

The identification of the green alga which is common to a large number of lichens has presented great difficulties in the past. Opinion has been based upon the assumption that the absence of spore formation in the lichen thallus is owing to the fact that the alga, on becoming a gonidium, is profoundly altered, so that it ceases to produce aplanospores or zoospores or both. As spore formation of the gonidium has now been clearly demonstrated (figs. 2, 5 and 6) the standpoint as to the identification of the alga is completely changed. The weight of evidence is in favour of the alga being a species of *Chlorella*.

The photomicrographs of microscope slides were voluntarily prepared by Mr J. H. Pledge, F.R.M.S., who had at his disposal, by permission of the management, the apparatus of the physical laboratory of the Kodak Company's factory at Harrow. I take this occasion for expressing my grateful thanks to him for the great skill he displayed in this work.

Having had the opportunity of discussing with Miss A. Lorrain Smith some of the matter brought forward in this communication, I thank her for valuable advice and criticism.

NOTE.

Since reading the above paper I have noted that the alga *Protococcus* is the gonidium of the lichens *Dermatocarpon aquaticum* and of *D. miniatum*. It is not so in the case of *D. hepaticum* and *D. cinereum*.

As regards the two former, the gonidium resembles in size, and in its mode of multiplication by binary fission, the free *Protococcus* obtained from the bark of trees, palings, etc.

This alga has not been modified in shape and size to any appreciable extent on becoming the algal constituent of a lichen.

DESCRIPTION OF PLATE I.

Fig. 1. *Evernia prunastri*. Transverse section of the thallus showing gonidia arranged in spherical groups. × 1000.

Fig. 2. *E. prunastri*. Normal gonidia showing variation in size of the cell according to age. Photograph especially developed to show cell-wall. × 1000.

Fig. 3. *E. prunastri*. Normal and sporulating gonidia. Some are undergoing changes previous to sporulation. × 1000.

Fig. 4. *E. prunastri*. An isolated gonidium containing sixteen daughter-gonidia, not fully developed. × 1000.

Fig. 5. *E. prunastri*. An isolated gonidium containing sixteen fully developed daughter-gonidia. The mother cell-wall has partly disappeared. × 1000.

Fig. 6. *Cladonia digitata*. A group of liberated daughter-gonidia, invaded by hyphae, being forced apart. Two twin-gonidia are on the left. × 1000.

LIST OF PAPERS AND PUBLICATIONS QUOTED.

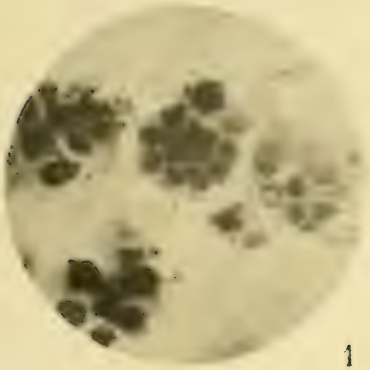
(1) De Bary, A.—Comparative Morphology and Biology of the Fungi, etc. Oxford (1887).

(2) Bornet, E.—Recherches sur les Gonidies de Lichens. Ann. d. Sci. Nat. 5th Série, xvii (1873).

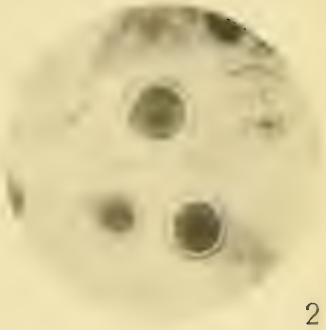
(3) Chodat, R.—Matériaux pour la Flore Cryptogamique Suisse, vol. iv, fasc. 2 (1913).

(4) Danilov, A. N.—Ueber das gegenseitige Verhältnis zwischen den Gonidien und den Pilzkomponenten in der Flechten Symbiose. Bull. Jard. Imp. Bot. St Pétersbourg, tom. x, livr. 2 (1910). Translation Journ. Bot. July 1918.

(5) Famintzin, A. and Baranetzky, J.—Beitrag zur Entwickelungsgeschichte der Gonidien- und Zoosporen-Bildung bei Physcia parietina. Bot. Zeit. (1867), 189–190. Mémoires de l'Acad. St Pétersbourg, vii, Série ii (1868).



1

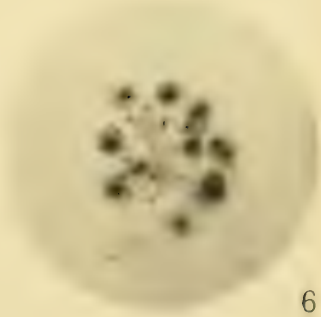


2

3

4

5



6

(6) Grintzesco, M. Jean.—Recherches expérimentales sur la morphologie du *Chlorella vulgaris*. Revue Générale de Botanique, xv (1903).
(7) Paulson, R. and Hastings, Somerville.—Relation between Alga and Fungus of a Lichen. Linn. Soc. Journ. Bot. xliv, pl. XXI, fig. 1 (1920).
(8) Schwendener, S.—Die Algentypen der Flechten-Gonidien. Basel (1869), Tab. III, fig. 25.
(9) —— Untersuchungen über den Flechtenthallus. Nägeli, Beitr. Wiss. Bot. 3, pl. VIII, figs. 10 and 11 (1868).
(10) —— Die Flechten als Parasiten der Algen. Verhandl. Schweiz. Ges. Basel (1873).
(11) Smith, A. Lorrain.—Monograph of British Lichens. London, vol. 1, 1918.
(12) West, G. S.—Cambridge, Botanical Handbooks. Algae. Vol. 1 (1916).
(13) Woronin, M.—Mémoire sur les Gonidies du Parmelia pulverulenta. Ann. d. Sci. Nat. 5th Série, xvi (1872).

THREE FUNGI IMPERFECTI.

By Jessie S. Bayliss Elliott, D.Sc., and Helena C. Chance, M.Sc.

Three species of *Fungi Imperfecti* of considerable interest were found growing on some dead twigs of *Pinus sylvestris* picked up in the Oxshott Woods, Surrey, January 1919.

One fungus was somewhat similar to a *Cytospora*, having its sporophores forming a lining layer to the walls of chambered pycnidia: it is allied to *Cytodiplospora*, from which it differs in having bi-septate spores when mature: on this account it must be placed in a new genus which we propose to call Cytotriplospora.

Cytotriplospora, gen. nov.

Stromata erumpentia, pustularia, peridermii laciniis cincta, intus pluri-locellata. Sporulae copiosae, allantoideae, hyalinae, primo continuae, deinde biseptatae, sporophoris longioribus suffultae.

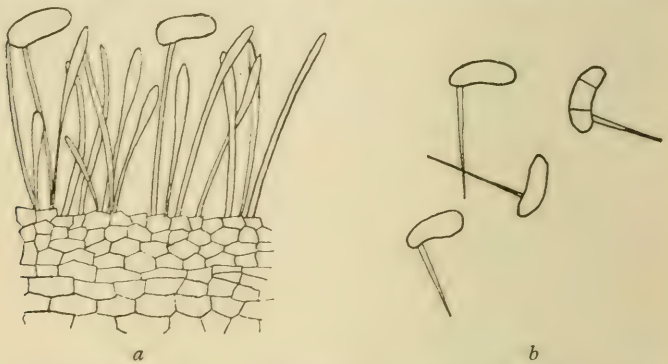
Cytotriplospora Pini, sp. nov.

Pycnidia subconferta, breviter parallele et longitudinaliter seriata, oblonga, 1–6-locellata, atra, 300–500 μ diam., tandem apice erumpentia; sporulae allantoideae, hyalinae, continuae, deinde 1–2-septatae, 15 × 4·5 μ, sporophoris simplicibus, filiformibus, rectis, acutis, circa $1\frac{1}{2}$ quam sporula longioribus suffultae; sporophorae cum sporulis maturis dilabuntur, et tunc spinae vel cilii speciem ostendunt.

Hab. in ramulis *Pini sylvestris*, Oxshott Woods, Surrey.

Pycnidia rather crowded, occurring in irregular lines, somewhat parallel, following the long axis of the twig, oblong,

1–6-chambered, black, 300–500 μ in diameter, at length erumpent at the summit; spores sausage-shaped, hyaline, at first unicellular, at length 1–2-septate, 15 × 4·5 μ; when mature the sporophore breaks away, remaining attached to the spore, and looking like a spine or cilium; sporophores simple, slender, straight, and pointed, about 1½ times the length of the spore.



a *b*

a. Sporophores × 800. *b*. Spore with attached sporophores × 800.

The method of growth of the spores is unusual. They are at first oval, and form a continuation of the axis of the sporophore, then they become cylindrical and curved, and bend over so as to become obliquely attached to the sporophore*.

Spores which bear a great resemblance to these occur in *Pestalozzina Rollandi*, growing on pine leaves, a species which was recorded by Fautrey†. The spine-like structure attached to these spores, Fautrey considered a true cilium, and consequently placed his species in the genus *Pestalozzina*, a genus with ciliate spores. The attached sporophore of *Cytotriplospora Pini* is very much like a cilium and, as Fautrey does not figure the method of growth of the sporophores of *Pestalozzina Rollandi*, it is probable that his so-called "spine" was a sporophore. In this case *Pestalozzina Rollandi* would be a form of this fungus (*Cytotriplospora Pini*) growing on leaves, differing somewhat from the form it assumes on the stem, and should be considered as merely a leaf-form of *Cytotriplospora Pini*. Such a state of things is not unusual in the *Sphaeropsideae*, for there are several species of these fungi which may occur on the stems and leaves of the same plant; when on the stems they have pycnidia, but are without them on the leaves; for instance

* [Mr F. A. Mason has forwarded to me a scale of *Picea excelsa* collected at Reeth, Yorkshire, May 1920, with *Cytotriplospora Pini* on it—identified by Mr W. B. Grove. J. R.]

† See Rabenh. Krypt. Fl. vol. VII, p. 630.

Phomopsis Tulasnei on the stems of the Maple has pycnidia, and *Glocosporium acerinum*, which is the same fungus growing on the leaves, is without them.

Another fungus proved to be *Naemospora Strobi* Allescher*, which has not hitherto been recorded for the British Isles: this fungus we had also found two months previously growing similarly on *Pinus sylvestris* twigs in Pool Hollies Wood, Sutton Park (Warwick).

NAEMOSPORA STROBI Allesch.

The spores are contained in irregularly shaped cavities more or less fused at maturity, formed under the periderm, the walls having a yellowish tinge; the spores are of two forms, sausage-shaped with a slight depression, 3–4 × 1·5–2 μ, and rod-shaped, 3–4 × 1–2 μ, unicellular, hyaline, numerous; when mature they are exuded in mucus from irregular, somewhat rounded, slits in the bark, and form cream-coloured tendrils; sporophores straight and pointed, fasciculate in bundles of 3–6.

In Allescher's description of this fungus only one kind of spore is mentioned—the rod-shaped, the form which we find only in very mature specimens.

This possession of two kinds of spores, or of spores which assume different shapes, is a common feature in quite a large number of these *Fungi Imperfecti*.

The third fungus was *Fusicoccum bacillare* S. and P., but this specimen differed from that described by Allescher† in having no white disc and larger spores (17–20 × 3 μ); it is interesting as forming a transition between the two varieties *Fusicoccum bacillare* var. *dolosa* and *F. bacillare* var. *acuum*: it resembles the former in having no white disc and the latter in possessing larger spores.

Fusicoccum bacillare grows on the bark of *Pinus sylvestris*, but the variety *acuum* grows on the leaves, so that this fungus, like *Cytotriplospora Pini*, bears out the theory that is now becoming generally accepted, that the same fungus may occur on the stems and leaves of the same plant, and yet have a somewhat different form on the leaf from that on the stem.

We wish to take this opportunity of thanking Mr W. B. Grove for his kind help in the identification of these species.

* See Rabenh. Krypt. Fl. vol. VII, p. 540.
† See Rabenh. Krypt. Fl. vol. VI, p. 550.

TWO NEW BASIDIOMYCETES.

By H. Bourdot.

Among the interesting species which Mr A. A. Pearson has been kind enough to send me, are two which have not yet been described. One of them has been gathered several times in France by M. A. Galzin, and it may be that the species are not very rare; but they are so delicate in substance and disappear so quickly that few observers in the field have paid any attention to them.

One ought perhaps to mention that besides the difficulty of recognising these minute species, there must be considerable hesitation in recording them as new. The reason for this is that certain Basidiomycetes are fertile at a very early or larval stage when they present a very different appearance from the fully developed plant.

Corticium rubropallens (Schw.), *C. lividum* Pers. etc. form at first a pruinose film barely visible; the basidia which are already fertile grow in tufts on the few mycelial hyphae that are scattered over the substratum. In the case of such species, the microscopic characters are practically the same as in the adult stage, and usually one is given a clue to their identity by parts of the sporophore which, especially towards the centre, are more developed and more normal.

In other cases, *Stereum purpureum* Pers., *S. Karstenii* Bres., *Coniophorella olivacea* (Fr.) Karst., the early form is more distinct, and the cystidia especially are so profoundly modified that identification is only possible if one follows for some time the development of the fungus. Some Stereums may start in two ways: in the form of tubercules, small discs or patches with well-defined edges; or in a diffused form, which remains for some time hypochnoid or corticioid. This last mode of development is fairly frequent in *Stereum purpureum*, and one can easily observe it on trunks or branches of poplar which remain some years on the ground, or in the timber yard. Towards the end of the summer the fungus forms a rather light pruinose film, which is already fertile and gradually acquires first a pellicular then a membranous, pale yellow hymenium. The microscopic structure is then almost exactly that of *Peniophora sublaevis* Bres. and at this stage of development the vesiculose cystidia characteristic of *Stereum purpureum* are either completely absent, or very rare. There are, however, numerous hymenial cystidia which are slenderly fusiform, of the same

diameter as the basidia and projecting 25 to 30 μ. After some months growth, the fungus may, by the joining up of several patches, cover a wide area; then the central part becomes atrophied and finally disappears while the peripheral parts, on the contrary, thicken, acquire a purple tint, and tend to turn up at the edges which become covered with hairs; the hymenial fusiform cystidia are replaced gradually by vesiculose cystidia which rise from the sub-hymenial region.

On the other hand there are species with such a tenuous poorly developed appearance that they would be taken either for stunted specimens or for the early stages of more robust forms analogous to those mentioned above. They are, however, fully developed and will always be found in this form. The best instance is *Peniophora accedens* Bourd. et Galz. a small furfuraceous patch of a few millimetres, barely visible to the naked eye, which may easily be taken for dust covering pieces of old wood. We expected to find this plant develop after the manner of *Peniophora glebulosa* or like an *Odontia*, but for fourteen years the gatherings of this minute *Peniophora*, which have numbered hundreds, and have been made in districts widely apart, have never shown greater development, and in all its characters there is such remarkable constancy that one is forced to the conclusion that such forms, until proof to the contrary is brought forward, must be described as autonomous species.

There is much to be done in this part of Mycology which has been for a long time neglected. These examples are enough to show that it is often more important to observe the living plant, than to seek among herbarium specimens for the characters of new species.

The Corticium that Mr Pearson has found was in a luxuriant state of vegetation, occupying the whole of the interior of a pine log rotting on the ground. It was, however, barely visible to the naked eye; it is a ceraceous-pruinose efflorescence, which carpets the narrow interstices which are found between the fibres of wood attacked by *Merulius himantioides* Fr. In the dry state, when looked at with a magnification of about 80 diameters, only a fine network can be observed, fairly regular and made up of white brittle fibres. Its subnavicular spores place it apart from all the ceraceous Corticiums, to which one would compare it. The only species which has microscopic characters approaching it is *Corticium filicinum* Bourdot, but this is a common species in France, which has never varied its habitat on fern débris and from its external characters it is most unlikely that any true

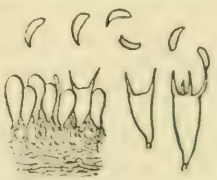


Fig. 1.
Corticium Pearsonii.

relationship can exist between these two plants. I consider *Corticium Pearsonii* as a distinct species which will reappear under the same conditions of habitat and temperature.

CORTICIUM PEARSONII n. sp.

Adnatum, tenuissimum; 20–50 μ crassum, in rimulis ligni cariosi latitans, ceraceo-pruinosum, grisellum, vix continuum, mox furfuraceo-granosum, in sicco lineolis crustaceis albis, eximie reticulatis constans. Hyphae hyalinae, dense intricatae, rarius distinctae; 2–2·5 μ, tenuiter tunicatae, nodulis sparsis; hymenium basidiis et rarioribus hyphis sterilibus, aequilongis compositum; basidia obovata, 9–15 × 5–6 μ, 2–4 sterigmatibus demum arcuatis, usque ad 6 μ longis; sporae hyalinae, anguste clavulatae, lateraliter depressae vel subarcuatae, 4·5–6 × 1·5–2 (–2·5) μ.

In rimulis trunci pinei pullulans, Locus Weybridge, Surrey. Sept. ad finem Octobris 1920; legit A. A. Pearson.

The genus *Heterochaete* Pat. was established for species of *Sebacina* with erect emergences on the hymenium consisting of compacted sterile hyphae with or without cystidia. *Heterochaete dubia*, Bull. Soc. Mycol. Fr. xxv, p. 30 (1909), placed doubtfully in this genus, does not in fact belong to it. This species has no emergences composed of sterile hyphae but only projecting cystidia which brings it into a group of the Sebacineae analogous to *Peniophora*. It is therefore logical to establish a section or sub-genus for the species of *Sebacina* with cystidia, as has been done for the Sebacineae with gloeocystidia.

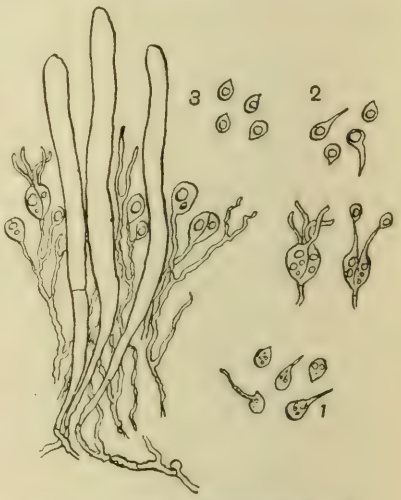


Fig. 2. *Heterochaetella crystallina.*
1. Spores of the British specimen.
2. Sp. of no. 15208.
3. Sp. of no. 16765.

This new sub-genus Heterochaetella till now only included *H. dubia* with allied forms or species which have not yet been published, and which are distinguished by the spore and nature of the cystidium; in *H. dubia* this is of the same type as in *Peniophora glebulosa* and in other forms, of the type found in *P. subalutacea* or *cineracea*.

The new species, described below, is differentiated from the

others by its cystidium with thin walls, differing however from a glococystidium in that the walls are rigid and project a long way. *H. crystallina* comes therefore into *Heterochaetella* for the same reasons that numerous species have been placed in *Peniophora* which have cystidia with thin walls, such as *P. argillacea* Bres., *P. clavigera* Bres., *P. chordalis* v. H. et L., *P. detritica* Bourd. et Galz., etc.

This delicate species has the appearance of a loose thin crystalline film of ice. When older the film collapses, becomes less limpid, and more or less mucous. On drying the fungus contracts, cracks, and is reduced to fine scarious scales, which quickly disappear: when quite dry, there is left on the wood only a slightly polished stain difficult to see. The plant can be made to reappear if herbarium specimens are moistened, but only two or three times at most; after that it becomes absorbed into the pores of the wood. Doubtless such delicate plants might be preserved with advantage in alcohol.

HETEROCHAETELLA nov. subgenus.

Complectens *Sebacinae* species effusas, et genuinis cystidiis praeditas.

H. CRYSTALLINA n. sp.

Pusilla, ½–2 cent. diam. ceraceo-gelatinosa, limpida, setulis hyalinis sub lente hispidula, dein collapso-impressa, tenuissima, indeterminate et interrupte effusa; ambitu similari vel minus continuo, reticulato. Hyphae 0·5–3 μ, ramis hymenium penetrantibus et subinde emergentibus; cystidia tenuiter tunicata, cylindracea, obtusa, sparsa vel passim fasciculata, 60–180 × 7–12 μ, ad 10–45 μ emergentia; basidia obovate vel subglobosa 8–12 × 6–9 μ, longitudinaliter septata, 2–4 sterigmatibus subulatis 5–6 μ dein ad 15 μ longis; sporae hyaline subglobosae vel obovatae, plus minus basi apiculatae, saepe uniguttulatae, (4)–4·5–6 × (3)–4·5 μ, latere germinantes, vel apiculo tunc valde elongato, conico.

Ad ligna putridissima *Pini silvestris* Causse-Noir, Nov. 1914, Galzin, n. 16765; *Juniperi communis* St. Estève, maj. 1914, Galzin, n. 15206–15208, *Aveyron* in Gallia. Ad ligna *Pini silvestris* Horsley, Surrey in Anglia, Nov. 1920, et Feb. 1921, A. A. Pearson.

Further specimens of *H. crystallina* having been gathered in several places by Mr Pearson (always on pine wood in a very advanced stage of decay), it is possible to add some observations on the development and structure of this curious species. In its early stages, it is formed of minute receptacles, 40 to 160 μ in diameter, densely grouped, but distinct. The shape of

the receptacles is very variable, being sometimes hydnoid, sometimes attenuated at the base or substipitate, claviform or obovate, always more or less angular, and sometimes in the form of erect laminae, obovate, and bi-trilobed.

These small fruit bodies have one or more long hyaline hairs projecting at the apex or at the side. In their subsequent development, either by lateral growth or by the intercalation of new tubercles, they become confluent in a net-like manner and finally acquire the form of a continuous pellicle. The plant then, when growing well, is seen as a crystalline pellicle, surrounded by a more or less wide net-work, which resolves itself at the margin into distinct corpuscles. When dry, the reticulate portion resembles a delicate lace thread.

In the most perfect specimen examined, the cystidia are 100–130 × 7–15 μ and project up to 60 μ: they are accompanied by numerous gloeocystidia 3 to 7 μ in diam. which either project slightly or not at all. These gloeocystidia are linked by a series of gradations with the simple or branched paraphyses 1·5–3 μ in diam. or with the fertile hyphae which bear more or less elongated and club-shaped basidia. The hyphae, gloeocystidia and cystidia are bunched together at the base in tufts, as is usual in all species which start with a scattered growth and become confluent subsequently.

In certain parts of the trama, originating in the substratum, are found groups of pyriform vesicles 9–27 × 7–15 μ; these vesicles are not always present, but on the wood near one specimen of *Heterochaetella*, without however touching it, were found small grey pruinose patches which were entirely composed of these tufted vesicles. Is this a distinct species or can one look upon these vesicles as a sclerotic state comparable with *Aegerita candida* Pers. in its relation to *Peniophora aegerita* v. Hoehn. et L.?

NEW BRITISH HYMENOMYCETES.

By A. A. Pearson, F.L.S.

The identification of all the species included in this paper has been confirmed by Monsieur l'Abbé H. Bourdot, to whom I am much indebted. His letters have been freely used in the notes dealing with *Sebacina*. The specific names are used with the significance given to them by Bourdot and Galzin in their papers in the Bull. Soc. Mycol. Fr.

EXIDIA THURETIANA (Lév.) Fr. Hym. Eur. p. 694.

Effused in thick undulating pulvinate or tuberculate patches of a firm gelatinous consistency; opalescent when fresh, sometimes with a pink tinge; hymenium pruinose, finally collapsing into a thin horny yellowish film. Hyphae 1–2½ μ; basidia longitudinally septate 15–20 × 11–15 μ; spores hyaline, cylindrical, curved 15–20 × 5–7 μ. Grows abundantly on the underside of beech sticks lying on the ground.

The large spores and firm consistency are the distinguishing feature of this species.

Horsley, Surrey, Feb. 1920; Painswick, Gloucestershire, May 1920; Worcester, C. Rea, 1920.

SEBACINA Tul.

The species of Sebacina originally described possess a firm crust. The limits of this genus have, however, been extended to include mucous evanescent species.

In Sebacina (sensu stricto) the coriaceous subiculum is sometimes well developed, clavariiform as in *laciniata* Bull., *cristata* Pers., or like a Corticium as in *incrustans* Pers., *sebaceum* Pers. It is now realised that these are all variations of the same species.

But careful observation will show that the above forms, which are summer forms and often almost sterile, are replaced gradually in the autumn and winter by other forms where the coriaceous subiculum is reduced more and more until it disappears. The plant is then spread over the soil or débris and entirely gelatinous-mucous. This form is probably the true *Tremella epigaea* B. et Br. The same plant turned pruinose and bluish by abundant sporulation constitutes *Sebacina caesia* Tul. If growing on wood it might be the same as *S. ambigua* Bres. In all these plants the structure and the spores are the same; only the coriaceous hyphae so abundant on the first forms no longer exist in the last, where, however, the mucous hymenium

remains unchanged. The flat mucous forms are therefore indissolubly linked up with the coriaceous Sebacinas, and there is no point where a division could be made.

SEBACINA FUGACISSIMA Bourd. et Galz. in Bull. Soc. Myc. Fr. XXV, 1909, p. 28.

Effused in a very thin mucous hyaline greyish film, which disappears completely on drying or leaves only a slightly glistening trace barely visible *sub lente*. Hyphae 2–3 μ; basidia longitudinally septate 6–7 × 5–6 μ. Spores hyaline, cylindrical curved 4½–7 × 2½–4 μ.

Horsley, Feb. 1920 and Feb. 1921. On crumbling wood in the last stage of decay.

Since the original description of *Sebacina fugacissima* numerous gatherings have shown the species to be very variable. Some forms are less fugacious than others and the film may vary in thickness, but the structure is the same in all. There is, however, considerable difference in the spore. The commonest is 4½–5 × 3½–4 μ. The type is 6–7 × 2½–3½ μ. Others are 6–7 × 2–2½ and 6 × 4 μ.

There are other closely allied forms with larger spores, to which specific names have been given. It is difficult to define the limits and the value of these forms. The only certain fact is that they constitute a long and almost uninterrupted series.

CORTICIUM SPHAEROSPORUM (R. Maire) v. Höhn. et Litsch. in Sitzungsbericht. K. Akad. Wiss. Wien, CXVII, I, p. 1105, 1908 (= *Hypochnus sphaerosporus* R. Maire).

Thinly effused, arachnoid and porous under the lens, edge indeterminate; chalk white, sometimes with a yellow tinge; hyphae 2–4 μ thin-walled with clamp connections; basidia clavate 9–15 × 4–6 μ with 2 or 4 sterigmata 2–4½ μ long; spores hyaline subglobose or obovate, 1-guttulate, minutely warted with angular warts. 3–6 × 2½–4 μ (mostly 4½ × 4 μ).

Very like *Corticium confine* Bourd. et Galz. in the arachnoid strands covering the hymenium here and there, but easily distinguished by the verrucose spores.

Epping Forest, Oct. 1920 on beech log; Horsley, Feb. 1921 on oak stump.

CORTICIUM SUBMUTABILE v. Höhn. et Litsch. Op. cit. CXVI, 1907, p. 822.

Effused in a very thin pulverulent membrane, pale cream, sometimes with a deeper tint, edge similar; hyphae 1–3 μ thin walled, septate-nodulose, rarely distinct (no clamp connections observed); basidia clavate 8–12 × 4–4½ μ with 2 or 4 straight

sterigmata $2\frac{1}{2}$–$3\,\mu$ long; spores hyaline, sub-globose, attenuated at base, usually 1-guttulate, rough with short conical warts 3–$3\frac{1}{2} \times 2$–$2\frac{1}{2}\,\mu$.

On pine stick, Weybridge, Surrey, Sept. 1920.

PENIOPHORA SPHAEROSPORA v. Höhn. et Litsch. Op. cit. CXV, 1906, p. 1600.

Broadly effused, firmly attached to the substratum, 0·15 to 0·30 mm. thick, edge indeterminate, chalk white, smooth or papillate, waxy when fresh, not cracked when dry. Basidia clavate 25–35×6–$8\,\mu$ with 4 long subulate sterigmata. Cystidia abundant, cylindrical, usually narrowed at apex, thin walled, 35–85×5–$8\,\mu$ projecting above the hymenium. Spores globose 4–$7\,\mu$ diam. apiculate, colourless, smooth, 1-guttulate. Hyphae smooth, thin walled, somewhat nodulose, often anastomosing with frequent clamp connections, 4–$5\,\mu$ thick.

On fallen stick, probably alder. Weybridge, Nov. 1920, Rev. J. P. Alexander, C.J. and A. A. P.

PENIOPHORA LAEVIS (Fr.) Burt

Broadly effused, membranous, not closely adnate, at first white, then cream, more or less cracked when dry, edge radiately fibrillose; hyphae regular with few or no clamp connections, walls thin, the sub-hymenial hyphae 3–$4\,\mu$ diam. basal hyphae up to 7 or $8\,\mu$; cystidia fusoid 40–90×4–$7\,\mu$ with or without incrustation (6–$11\,\mu$) walls thin or slightly thickened; basidia very variable, 20–36×3–$7\,\mu$ (most frequently $35 \times 4\frac{1}{2}\,\mu$) with 2 or 4 sterigmata 4–$6\,\mu$ long; spores elliptical oblong, $4\frac{1}{2}$–$6 \times 2\frac{1}{2}$–$3\frac{1}{2}$ uniguttulate.

On birch bark, Weybridge, Nov. 1920.

HYPOCHNUS ROSEO-GRISEUS Wakef. et Pearson var. LAVANDULACEUS n. v.

Differs from the type in the greyish lavender colour of the hymenium, without trace of pink.

Found in abundance on the ground under *Castanea vesca* at Porlock, Somerset, Sept. 1920.

HYPOCHNUS GRANULOSUS (Peck) Burt. in Ann. Missouri Bot. Gard. III, 1916, p. 218 (= *Grandinia tabacina* Cooke and Ellis); *Zygodesmus granulosus* Peck; *Hypochnus claeodes* Bresad.

Effused in a thin separable membrane, granular, sepia, margin somewhat radiate, concolorous; hyphae loosely interwoven, thin walled, occasionally nodose-septate, $2\frac{1}{2}$–$4\,\mu$ diam. yellowish under the microscope; spores same colour as hyphae,

angular, sub-globose, aculeate, the body about 6 μ diam. Burt gives the habitat as rotten bark, and wood of frondose species. In France it is found on sandstone and chalk. The present specimens (Somerset, Sept. 1920 during Minehead foray) were on a pine stick and were rust coloured.

The specific name *tabacina* of Cooke and Ellis, though having priority is not now available as it is already used for Bresadola's species.

MUCRONELLA AGGREGATA Fr. Hym. Eur. p. 629.

Subiculum absent or occasional, teeth subulate, short, free, but arranged in groups, white then pale. Hyphae 2–4 μ with thin walls, clamp connections sparse, basidia cylindrical or clavate 10–20 × $3\frac{1}{2}$–5 μ; spores hyaline elliptical 4–6 × $2\frac{1}{2}$–4 μ.

Under old log in last stage of decay. Horsley, Oct. 1920, A. A. P. and Rev. J. P. Alexander, C.J.

NEW OR RARE BRITISH DISCOMYCETAE.

By Carleton Rea, B.C.L., M.A. etc.

Pustularia lecithina (Cke.) Rea. *Peziza* (*Humaria*) *lechithina* Cke. in Grev. IV, 110. *Helotium lechithinum* Massee, Brit. Fung. Fl. IV, 233.

In September 1920 Mr James Menzies sent me a fine gathering of this species from the neighbourhood of Perth. The hymenium varied in colour from egg-yellow to a deep red orange due to the position of the receptacles, growing either in water on the underside of a stick, or out of the water and exposed to the light. The asci are cylindrical, 250–290 × 15–18 μ, operculate, and do not turn blue with iodine. The spores are hyaline, elliptical, obtuse at both ends, 18–22 × 10–13 μ, 2-guttulate at maturity and accompanied by granulations. The paraphyses are hyaline, filled with large yellow oil drops in the upper portion, gradually enlarged upwards into the clavate apex, 265–300 × 4–8 μ, simple, or branched, septate, contents not turning green with iodine. The hypothecium is pseudoparenchymatous, averaging 50–60 μ in diam. Boudier in his Histoire et Classification des Discomycètes D'Europe, p. 70, doubtfully assigned this species to the Humariaceae, but it is clear from the extended diagnosis set out above that it must be referred to the Pezizaceae and placed in the genus Pustularia.

Ascophanus cervarius (Phill.) Boud. Phill. in Stevenson, Myco. Scot. 308, Brit. Disc. 100.

In August 1920 Mr Norman G. Hadden forwarded to me some specimens of this species growing on Red Deer dung from the Horner Woods, Somerset, and numerous examples were also found there at the autumn foray. The ascophore is quite pallid or whitish at first and it is only with age that it becomes chestnut-brown. The asci are cylindrical, abruptly attenuated at the base, 155–170 × 13–15 μ, operculate, not turning blue with iodine. The spores are hyaline, oblong elliptic, rounded at both ends, 15–17 × 8–9 μ, 1-guttulate. The paraphyses are hyaline, linear, 130–150 × 2 μ, often forked at the apices, septate.

Hyalinia turgidella (Karst.) Boud. Karst. Mon. Pez. 179, as *Peziza turgidella*, Rehm. in Rabh. Krypt. Fl. 1, 3, 680 and figs. 1–5, 651, as *Pezizella turgidella* (Karst.) Sacc.

Ascophores ·2–·4 mm. wide, *white, hyaline, becoming yellowish when dry*, gregarious, or somewhat scattered, waxy, sessile, globose, closed at first and when dry, then cup-shaped, and finally plane and convex, subglabrous or minutely downy. Asci fusiform clavate, 30–40 × 4–6 μ, apex obtusely pointed, inoperculate, foramen immarginate, pore turning slightly blue with iodine. Spores hyaline, oblong fusiform, 5–10 × 1–1·5 μ, with a small oil drop at each end, biseriate or obliquely uniseriate. Paraphyses hyaline, filiform, 35–45 × 1·5–2 μ. Hypothecium pseudoprosenchymatous. On dead grass stems, Perth, 11th July, 1920, Mr James Menzies.

Dasyscypha crystallina (Fuck.) Sacc. Fuck. Symb. Myc. 306. Rehm. in Rabh. Krypt. Fl. 1, 3, 873, as *Lachnum crystallinum* (Fuck.) Rehm.

Ascophore ·3–1 mm. wide, *yellowish white, becoming deeper, or golden yellow with age*, gregarious, waxy, stipitate, globose, closed at first, then cup-shaped; stem ·5–2 mm. long, thin; externally clothed (especially towards the margin) with erect, simple, straight, generally somewhat rough, septate hairs, 40–60 × 3 μ, *gradually enlarged into a clavate or knobbed apex*, 4–5 μ in diam., incurved when dry. Asci cylindric-clavate, 30–40 × 4–5 μ, apex rounded, 8-spored, inoperculate, pore turning blue with iodine. Spores hyaline, oblong fusiform, straight, continuous, 5–8 × 1·5–2 μ, 2-seriate. Paraphyses hyaline, lanceolate, 40–50 × 3–4 μ, often 1-septate towards the base. Numerous crystals of oxalate of lime present in the hymenium and interspersed between the hairs. On dead stems of *Cnicus arvensis* and other herbaceous plants, Perth, 6th June, 1920, Mr James Menzies. Easily known amongst the Dasyscyphae with colourless hairs, by the *knobby apex of the hairs*.

Urceolella deparcula (Karst.) Boud. Karst. Myc. Fenn. I, 150.

In July 1919 and 1920 Mr James Menzies sent me an abundant supply of this beautiful discomycete from the neighbourhood of Perth, growing on the dead stems of *Spiraea ulmaria*. The description of this species given in Massee's British Fungus Flora, IV, 497, as *Belonidium deparculum* Massee, is incorrect, and the one published by Cooke in Grevillia, XX, 38 should be followed as it is a translation of Karsten's original diagnosis. The margin of the receptacle is covered with thin, hyaline, flexuose hairs, 30–40 × 1–1·5 μ at the apex. The asci are *constantly 4-spored*, cylindrically clavate, 30–45 × 5–6 μ, not turning blue with iodine. The spores are hyaline; narrowly fusiform, 13–16 × 2 μ, multi-guttulate. The paraphyses are sparse, hyaline, slightly thickened upwards, 25–40 × 1 μ.

Niptera Taxi Rea.

Ascomata ·2–·6 mm. lata, *albida*, ceracea, gregarea vel subsparsa, sessilia, hemisphaerica, dein concaviuscula; margineque crasso, obtuso; substantia concolor, molliuscula. Asci cylindraceo-clavati, apice obtusi, 50–60 × 8–10 μ, octospori, foramine immarginato, apice jodo haud tincti. Sporae hyalinae, leves, ovato-ellipticae, interdum uno latere subcurvatae, 8–12 × 4 μ, *semper primo continuae*, 3–4-*guttulatae*, denique medio septatae, distichae. Paraphyses hyalinae, filiformes, septatae, aequales vel ad apicem clava oblonga, aut globosa, interdum biseptata terminatae, 55–65 × 2–4 μ. Ad corticem truncorum *Taxi baccatae* in societate *Peniophorae laevigatae*, Horsley, Surrey, 2nd May, 1920. Coll. A. A. Pearson. Distinguished amongst the whitish species of Nipterae by the spores constantly 3–4-guttulate from the very first and the habitat on bark of *Taxus baccata*.

Ascocorticium Bref. Bref. Unt. Myk. IX, 145.

Receptacle none, hymenium seated directly on the mycelium, effused, confluent, and *Corticium*-like. Asci small, 8-spored, short, broad, sessile, inoperculate, foramen immarginate. Spores hyaline, oblong ovoid, agglutinated together in an ovoid cluster near the apex of the ascus, and finally ejected together as in *Saccobolus*, but devoid of any surrounding membrane. Paraphyses sparse, cylindrical, slightly shorter than the asci, scarcely enlarged upwards.

Ascocorticium anomalum (Ellis and Harkness) Schroet. *Ascomyces anomalus* Ellis and Harkn. Syn. *Ascocorticium albidium* Bref. in Unt. Myk. IX, 145, see F. S. Earle in Bull. New York Bot. Gard. II (1903), 331.

Greyish white, effused, or in scattered patches, often confluent. Asci sessile, clavate or boot shaped, apex obtusely rounded,

18–22 × 6–8 μ, not turning blue with iodine. Spores hyaline, oblong elliptical, rounded at both ends, 4–6 × 2–2·5 μ, agglutinated together in clusters of eight. Paraphyses hyaline, sparse, narrowly cylindrical or filamentous, 12–16 × 1·5–2 μ. Basal hyphae hyaline, 2–4 μ in diam., sparsely septate. On bark of *Pinus sylvestris*, Weybridge, Surrey, Mr A. A. Pearson, 22nd November, 1920. This is a very interesting addition to the British Fungus Flora, because it represents the Inoperculeae immarginatae group of Discomycetae hitherto unknown in Britain.

UPON THE OCELLUS FUNCTION OF THE SUBSPORANGIAL SWELLING OF PILOBOLUS.

By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.

As is well known, the sporangiophore of Pilobolus shoots away its sporangium to a distance of several feet and therefore acts as a gun. The gun consists of three parts: (1) a basal reservoir which is at first densely filled with protoplasm and which, with the aid of rhizoids, serves to fix the gun firmly to the substratum, (2) a slender cylindrical stipe several millimetres long, and (3) a large oval subsporangial swelling. The shape of the stipe and of the subsporangial swelling is like that of an inverted Florence flask. The projectile—the sporangium—is seated on the free end of the subsporangial swelling, is discoid, is covered with an intensely black membrane, and contains many thousands of spores. *Pilobolus Kleinii* and *P. longipes* can both shoot their largest sporangia vertically upwards to a maximum height just exceeding six feet and to a maximum horizontal distance just exceeding eight feet.

When discharge of a sporangium takes place, the neck of the subsporangial swelling just beneath the sporangium is ruptured transversely, the wall of the swelling and of the stipe contracts elastically, and the cell sap is squirted out of the top of the swelling so that the sap carries the sporangium with it through the air. Hitherto, the swelling has been supposed to function merely as part of a squirting apparatus.

The subsporangial swelling of Pilobolus functions not merely as part of a squirting apparatus *but also as an ocellus* which receives the heliotropic stimulus which causes the stipe to turn the fungus gun toward the light. The swelling is transparent and refracts light like the bulb of a Florence flask filled with water. Its diameter is always greater than that of the black sporangium which it supports.

When the sunlight strikes upon one side of the swelling, the light rays are refracted through it and converge so as to form a spot of light on the other side. When the incident rays of light strike the sporangium head on and are exactly parallel to the long axis of the swelling, the spot of light which is formed by the rays entering that part of the swelling which bulges out beyond and around the sporangium, is symmetrically placed at the base of the swelling. Under these conditions there is physiological equilibrium and no heliotropic reaction takes place. When, however, the incident rays of light strike a swelling obliquely, the spot of light is placed on one side of the wall of the swelling in a manner which is asymmetrical for the swelling as a whole. Under these conditions, the protoplasm which is lighted by the spot of light, sends a heliotropic stimulus down to the protoplasm at the top of the stipe just beneath the base of the swelling. The top of the stipe then reacts by growing in length most rapidly on the side nearest to the spot of light and thus bending as a whole. As a result of this reaction, the swelling is moved about its base through an angle and the spot of light gradually passes downwards on the wall of the swelling until it comes to be symmetrically placed at the base of the swelling. As soon as the spot of light reaches this symmetrical position, a physiological state of equilibrium becomes established in the sporangiophore and the heliotropic reaction ceases. At the end of the turning movement the gun is directed toward the source of the brightest light.

In bright sunlight directed perpendicularly to the long axis of the swelling, the stipe of *Pilobolus longipes* was observed to turn the swelling and the sporangium through an angle of 90°, and thus complete its heliotropic reaction, in about one hour.

In *Pilobolus Kleinii* the protoplasm in the lower part of the subsporangial swelling and at the top of the stipe contains a red pigment; and, at the top of the stipe just above the stipe's motor region, the protoplasm is often heaped up in such a way as to form a strongly bi-concave, very red, centrally perforated septum. As shown by direct observations and by theoretical diagrams, this protoplasmic septum is admirably shaped and situated for receiving the light rays converging upon it when the gun is in a position of complete or almost complete physiological equilibrium. Its concave upper surface, its position with respect to the subsporangial lens, and its strong pigmentation which is especially marked on its upper surface, suggest a comparison in function with the retina of the eyes of certain Mollusca.

The diameters of the sporangium, the subsporangial swelling, and the motor region of the stipe below the swelling in a well-grown *Pilobolus Kleinii* were observed to be 0·43 mm., 0·76 mm.,

and 0·16 mm. respectively. A simple calculation based on these data shows that the sporangium, when head on to a beam of parallel light rays, casts a shadow which has an area 7·2 times that of a cross-section of the stipe. If there were no subsporangial swelling, the shadow of the sporangium would cut off the light from the top of the stipe before the ortho-heliotropic position had been completely attained. This would prevent the gun from being accurately directed toward the source of light. Evidently the difficulty of supplying the stipe with its required delicate heliotropic stimulus has been surmounted in the course of evolution by the intercalation between the sporangium and stipe of the large light-collecting subsporangial swelling. That part of the swelling which bulges out beyond the black sporangium receives the light and concentrates it by refraction upon the base of the swelling, the asymmetrical position of the spot of light so produced providing the stimulus to which the motor region of the stipe can react.

A model for illustrating the Pilobolus gun in its relations with light can be made for demonstrations to an audience as follows. Take a Florence flask, fill it with water, stuff a smooth plug of cotton wool down the neck as far as the base of the neck and then close the mouth of the neck with a cork. To represent the opaque sporangium, stick a plano-convex mass of moulding clay covered with black tissue paper over the flat surface of the flask's base so as just to cover it. As a source of light use direct sunlight or a beam from the arc of a projection lantern.

(1) To imitate the condition of the Pilobolus gun when in a state of physiological equilibrium. Hold the flask in the beam of light with its long axis parallel to the direction of the incident rays and its black base facing the rays. It will now be found that the rays of light falling on that part of the flask's bulb which bulges out beyond the black base are refracted so that they converge within the bulb and brilliantly illuminate the cotton wool plug at the junction of the flask's bulb and neck.

(2) To imitate the condition of the Pilobolus gun when not in a state of physiological equilibrium. Hold the flask in the beam of light with its long axis making a considerable angle with the direction of the incident rays and so that the rays fall obliquely upon the flask's black base. It will now be found that the cotton wool plug is no longer brilliantly illuminated but that a spot of light is formed by the refracted light rays upon the side of the bulb.

(3) To imitate the movement of the spot of light down the side of the subsporangial swelling of the Pilobolus gun when the stipe, responding to a heliotropic stimulus, is turning the subsporangial swelling and sporangium through an angle. Hold the flask as just described, so that the spot of light is upon the

side of the bulb. Now turn the flask so that its axis gradually assumes a direction parallel to that of the incident rays. During this turning movement one can observe that the spot of light gradually moves down the side of the bulb until finally it takes up a perfectly symmetrical position on the cotton wool plug, the plug thus again becoming brilliantly illuminated.

(4) To show that if the cell-sap in the subsporangial swelling were replaced by air, the swelling would not act as a lens. Hold the flask in the beam of light as described in the first experiment. The light is refracted on to the cotton wool plug. Remove the water from the flask without removing the plug. Now hold the flask in the beam of light in the same position as before. The light is no longer refracted on to the plug.

Pilobolus lives in fields, etc., on the dung of herbivorous animals. By directing its guns toward the source of the brightest light, it is enabled to shoot its sporangia into open spaces and, therefore, away from the dung masses and on to grass and other herbage. The sporangia are very adhesive and, especially after they have dried, stick tightly to whatever they have struck. Heavy rain storms do not dislodge them. Herbivorous animals eat grass and sporangia together. The spores pass through the alimentary canal of cattle and horses unharmed and germinate in the solid excreta as soon as they have been dropped.

In the heliotropic reaction of Pilobolus which is caused by the asymmetrical position of a spot of light we have a clear proof of the theory, first suggested by Haberlandt*, that heliotropic reactions may take place in plants through ocellus action.

The sporangiophore of Pilobolus, as far as I am aware, is the only ortho-heliotropic plant organ known which takes up its positively heliotropic position owing to the possession of a special light-perceiving cell structure.

Pilobolus may be well described as a fungus with an optical sense organ or simple eye, and in using its eye for laying its gun, it appears to be unique in the plant world.

The above is an abstract of a paper read December 10, 1920, at Guelph at the second annual meeting of the Canadian Branch of the American Phytopathological Society and again on December 28 at Chicago before the Physiological Section of the Botanical Society of America. On the latter occasion the model described in the abstract was successfully used to demonstrate the lens effect of the subsporangial swelling to a large audience. A fuller description of my observations, accompanied by illustrations, is in preparation for the press.

The University of Manitoba, Winnipeg,
February 1st, 1921.

* G. Haberlandt, Die Lichtsinnesorgane der Laubblätter, Leipzig, 1905.

ON THE LIFE HISTORY AND MORPHOLOGY OF UROCYSTIS CEPULAE

With Plate II.

By T. Whitehead, A.R.C.S.

Laboratory of Plant Pathology, University College, Bangor.

Urocystis Cepulae is the cause of a destructive smut disease of onions which has resulted in thousands of acres of land in the United States being rendered unsuitable for the growth of this crop. The existence of the disease in several localities in Great Britain (1) resulting in some years in a total loss of the crop has shown the necessity for taking steps to eradicate this smut, or at least to restrict it to those places where it now occurs.

The present investigation was undertaken concurrently with the laying down of field experiments with a view to opening up new lines of attacking the problem of control. It is mainly concerned, therefore, with those features of the life-history and morphology of the fungus, a knowledge of which would best serve the immediate purpose in hand.

Historical.

In 1889 Thaxter (2) published an account of the history of the disease up to that date, together with a general description of the causal fungus. So far as the writer is aware no further attempt has been made to study the life history of *Urocystis Cepulae* though much has been written on suggested measures of control.

It is desirable to give here a short summary of the history of the disease since Thaxter's paper is inaccessible to most workers in this country. Indeed the present work was well advanced before the writer, through the kindness of Prof. Thaxter was able to obtain his paper. Onion Smut has been known in Connecticut since 1860. It first attracted attention as a serious disease in Massachusetts in 1869–70. About 1876 the fungus was given its present name by Mr C. C. Frost of Brattleborough, Vermont. Previously it was referred to the genus Peronospora. A short account by Farlow appeared in 1876–77 and this was followed in 1889 by Thaxter's paper mentioned above to whom most of our present knowledge of the fungus is due.

Thaxter gives the distribution of the smut as Connecticut, Massachusetts, Ohio, Pennsylvania and possibly several other

Eastern States; the neighbourhood of Paris and Rouen and probably also in the south of France. In Germany it was only known with certainty at Leipzig.

Since 1889 it has spread in the United States as far west as Wisconsin and Iowa; being observed for the first time in the latter state in 1912 (3).

The occurrence of the disease in this country has been described by Cotton (1) who also mentions the fact of its appearance in Denmark.

General appearance of the Disease.

The first indication of the disease is the appearance of one or more elongated, dark patches showing through the translucent outer tissues of the cotyledon when the plant is in second leaf. These opaque patches, indicating the formation of chlamydospores, usually occur just below the "knee" of the cotyledon but occasionally also in the upper part of the leaf. At first the sporogenous mass is embedded in the tissues, but, as the spores mature the mesophyll and epidermis of the cotyledon are ruptured and the spores are exposed as a black fibrous mass in the longitudinal fissure so formed. At the Northumberland centres, where the crop is left unthinned, the death of the plant usually takes place at this stage, but in other localities where onions are grown as an ordinary crop after thinning, successively younger leaves become infected until the plant has developed a bulb of fair size. In those latter cases the crop will usually "grow out" of the disease. Both onions and leeks are susceptible.

The Chlamydospores. The sporogenous mass is composed of immense numbers of chlamydospores which are usually considered to be homologous with the teleutospores of the Uredineae. Each spore consists of one, or very rarely two, central fertile cells surrounded by as many as twenty sterile vesicles or pseudospores; the whole spore ball varying from 15–20 μ in diameter. The fertile cell is from 11–14·5 μ in diameter and its shape, at first globular, usually becomes irregularly polyhedral owing to the pressure exerted by the developing sporogenous mass. It is uninucleated and contains dense granular cytoplasm. The wall is brown in colour, thick (1 μ) and non-laminated. No division into exospore and endospore has been observed nor can germ pores be seen even with the highest magnification ($\times$ 2250). The sterile peripheral cells are closely adpressed to the central spore-wall, they are devoid of protoplasm and possess relatively thin walls. The spore ball is extremely resistant to the action of concentrated mineral acids. The vesicles becoming inflated as the acid penetrates the walls indicates the

extreme impermeability of the central spore wall. After prolonged treatment the vesicles separate in the form of round discs.

Viability of Chlamydospores. No useful information based upon observations in this country is available, but in the United States the period during which spores remain viable is often given as at least twenty-five years and in a recent text-book (4) it is stated that there is no evidence of infected land ever becoming clean.

Germination of Chlamydospore. The germination of the spore ball has only been observed under the artificial conditions of the laboratory. In nature we may assume that a resting period after maturation is a necessary preliminary to germination. All attempts by the writer to induce fresh spores from the living leaf to germinate have failed, though Thaxter succeeded in germinating them in onion juice. After drying for about a month the spores were germinated with difficulty by first immersing the leaves in a freezing mixture at -25° C. for twenty-four hours. When, however, spores which had been air dried for some sixteen months were used, germination was effected without the preliminary freezing. The spores were obtained in a surprisingly pure condition from the leaves, but the precaution was adopted of immersing the fissured leaf in 0·1 % mercuric chloride for five minutes and then washing in sterilised distilled water before preparing hanging drops in sterile van Tiegham cells. Occasionally circular or pear-shaped resting spores of an undetermined fungus were present in the hanging drops and a few of them germinated, but they in no way obscured the observations on the germination of Urocystis.

On germinating, one or rarely two germ tubes or promycelia penetrate the spore wall between the sterile cells. Germination in water is slow and the promycelium ceases to grow after attaining a length of some 40–50 μ. Minute ovate sporidia are developed laterally upon the promycelium.

In onion juice, germination is much more rapid and the germinal hyphae are much stouter. They branch and anastomose repeatedly so that under favourable conditions a mycelial plate some 0·25 mm. in radius may be formed in forty-eight hours. Sporidia much larger ($7{\cdot}4 \times 3{\cdot}5\ \mu$) than those developed in water are produced laterally and sometimes occur superimposed in pairs. Thaxter states that in none of his cultures did any yeast formation take place as described in other species by Brefeld. In the present investigation, however, a hanging drop which had partially dried up was again flooded with onion juice upon which the sporidia separated from the hyphae and commenced to bud freely. A comparison of figs. 4 and 5 which

show the same germinal hyphae three days and thirteen days respectively after germination indicates that budding may occur whilst the sporidia are still attached to the hyphae. The conditions determining the budding of the sporidia are as yet obscure though one factor is certainly the presence of nutriment in a concentrated form.

It appears probable that budding or yeast formation is abnormal, and may not take place under natural conditions.

Conjugation of sporidia has not been observed.

Germination of Sporidium. The germination of sporidia in water has not been seen, but in onion juice one or rarely two polar germinal tubes were produced which ceased to grow after reaching a length of about 15 μ.

Infection of Host Plant.

It is now firmly established that only seedlings are susceptible to attack; transplants and setts not being affected (5). Thaxter showed that infection is wholly subterranean; a statement which has been repeatedly confirmed by the writer. It is difficult, however, to determine the point at which infection takes place since primary infection and sporulation cannot be demonstrated in the same specimen owing to the early death of the vegetative mycelium. Pot cultures of onions grown in soil contaminated with onion smut showed sporulation invariably within 2 mm. of the collar (i.e. junction of root and cotyledon) and frequently in the collar itself. This observation strongly suggests the collar region as the one at which infection normally takes place. The probability that this is correct is increased by the fact that hyphae indistinguishable from those of *Urocystis cepulae* could be demonstrated in the root hairs in the collars of very young seedlings grown in smutted soil.

Thaxter suggests that since spore masses may occur at the leaf tip infection may be possible also through the cotyledon before appearing above ground. Whilst this is, of course, possible, there is no experimental evidence in support of this view and it should be pointed out that the sporogenous hyphae frequently produce spore masses at intervals in the cotyledon, so that, externally, the dark patches appear to be separated by healthy tissue. It may well be, therefore, that sporulation at the leaf tip is only an extreme case of this discontinuous spore formation.

Method of Infection. The exact method of infection, i.e. whether sporidial or by direct penetration of the promycelium does not appear to have been satisfactorily demonstrated for any species of Urocystis, though Plowright (6) states that he successfully inoculated the leaf of *Ranunculus repens* with the

sporidia of *Urocystis Anemones*. An attempt to determine the relative importance of the sporidial germ tube and promycelium in securing infection was made by the writer in the following way. Young roots severed from healthy seedlings were fixed to coverslips with Canada Balsam. Chlamydospores germinating in water were then sown on the roots and the coverslips inverted over Van Tiegham cells. The promycelia produced by the chlamydospores grew over and amongst the root hairs but in no case were they observed to penetrate the walls. As, however, it proved to be impossible to see whether sporidia were produced on the promycelia, the attempt failed in its main object; only succeeding, in fact, in demonstrating that infection does not invariably occur when a promycelium comes in contact with an onion root.

Growth in Host Plant.

Once inside the host plant the hyphae develop intercellularly at approximately the same rate as the cotyledon grows in length. As in other members of the Ustilagineae the mycelium is evanescent and is difficult to trace far from the region of sporulation. The hyphae are sparsely septate and branching occurs at relatively infrequent intervals. These branches usually turn sharply forward and grow along the longitudinal walls, so producing a mycelium characterised by parallel hyphae. At intervals, which are long in the non-sporulating region and short in the part of the leaf in which sporulation occurs, hyphal branches pass along the end walls of the host cells and anastomose with hyphae growing at a different tangential or radial level. Branched haustoria resembling the intercellular hyphae are produced but do not form a prominent feature of the mycelium. As the spore forming region is approached the hyphae branch much more frequently until a compact mycelium is developed in which individual hyphae are difficult to trace. A pseudoparenchyma, however, is not produced nor is there any gelatinisation of the hyphal walls as described in other species of Urocystis (6).

The sporogenous mycelium is practically confined to the mesophyll lying between the vascular bundles. Only rarely is the phloem invaded and spores have never been found in the outermost layers of the mesophyll or in the epidermis.

Development of Chlamydospore.

The development of the chlamydospore or spore ball is not easy to follow owing to the denseness of the mycelium in which the spores are produced. Most success has been obtained by fixing in Carnoy's fluid young seedlings in which sporulation had just commenced and cutting thick (12–18 μ) longitudinal

sections. The sections are then stained in lacto-phenol-anilin blue and washed out with absolute alcohol until only the hyphae and young spores remain deeply stained.

The first recognisable stage is the formation of a knot of hyphae by the interweaving of short branches from one, or more usually, several neighbouring hyphae. The central hypha swells up at the tip to form the central fertile spore, which at this stage is thin walled and contains a single large nucleus embedded in the dense granular cytoplasm. Gradually the spore wall is thickened and modified into some form of lignocellulose. During the process the surrounding hyphae become adpressed to the spore wall, develop septa at short intervals and round themselves off to form the investing sterile cells. These sterile cells thicken their walls slightly and ultimately lose their protoplasmic contents. The chlamydospores are not formed in any definite order since contiguous spores are often at very different stages of development. The increasing pressure due to this constant production of spores gradually forces the mesophyll cells widely apart and ultimately ruptures the epidermis. The spores fall to the ground and after passing through the necessary resting period germinate and begin the life cycle again.

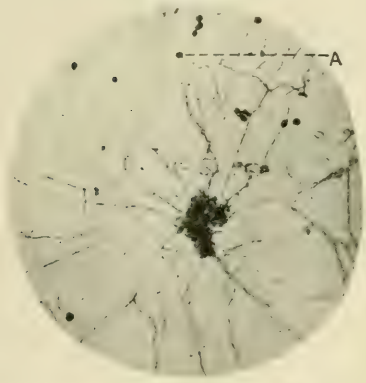
The writer desires to express his thanks to Prof. Thaxter and to the Connecticut State experimental station for kindly furnishing him with a copy of Prof. Thaxter's paper on *Urocystis Cepulae*.

Summary.

The life history of *Urocystis Cepulae* is relatively simple, chlamydospores giving rise to promycelia which develop sporidia laterally. This observation, originally made by Thaxter, and confirmed by the writer disposes of the view now held that the terminal production of sporidia is a generic character of Urocystis. There is no conjugation of sporidia. Under suitable conditions the sporidia may bud repeatedly though this probably does not take place normally. Infection is in all probability *via* the root hairs in the collar region. There is no interpolation of gonidia in the life cycle as in some genera such as Tuburcinia. The cytology of the fungus has not been studied in the present investigation.

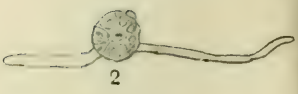
BIBLIOGRAPHY.

(1) Cotton, A. D.—Onion Smut—A disease new to Britain. Journal of the Board of Agriculture, vol. xxvi, No. 2, 1919.
(2) Thaxter.—The "Smut" of onions. Annual Report, Connecticut Agricultural Experiment Station, 1889.
(3) Pammel and King.—Iowa State Bul. No. 131.
(4) Hall and Stevens.—Fungoid diseases of Economic plants, 1913.
(5) Reddick, D.—West N.Y. Hort. Soc. Proceedings, No. 58, 1912.
(6) Plowright.—British Uredineae and Ustilagineae, 1889.

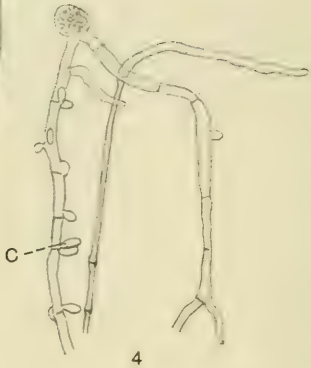


3

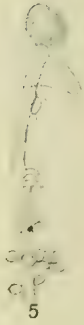
1



2

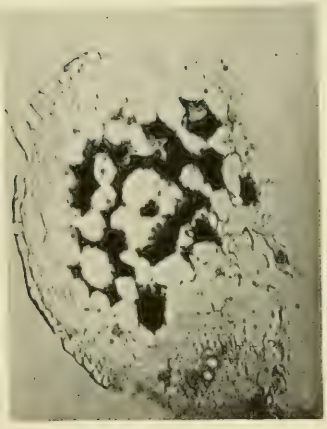


4

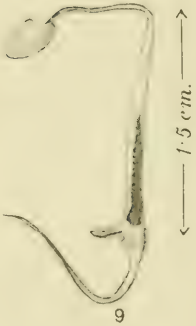


5

7



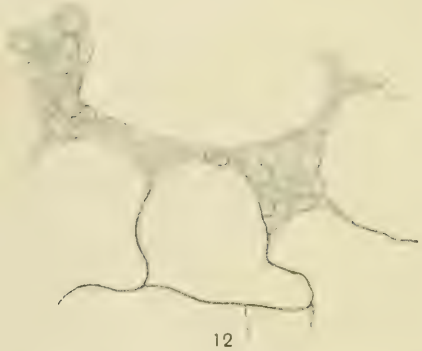
11



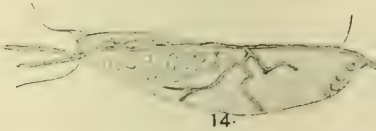
9

10

8



12

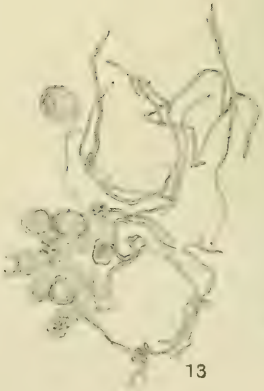


14

17

15

16



13

18

EXPLANATION OF PLATE II.

Fig. 1. Germinating Chlamydospore. × 400.
Fig. 2. Germinating Chlamydospore, showing two germinal hyphae. × 400.
Fig. 3. Microphotograph of Chlamydospores germinating in onion juice hanging drop. (A) Germinating Chlamydospore shown in detail in figs. 4 and 5.
Fig. 4. Formation of Sporidia (*c*) after 48 hours in onion juice hanging drop. × 400.
Fig. 5. Appearance of same hypha as in fig. 4 after 13 days showing budding of sporidia whilst attached to hypha. × 400.
Fig. 6. Sporidium budding in onion juice hanging drop. × 400.
Fig. 7. Germination of Sporidium, one polar germinal hypha. × 400.
Fig. 8. Germination of Sporidium, two polar germinal hyphae. × 400.
Fig. 9. Young onion seedling showing sporulation in collar.
Fig. 10. Hyphae in root-hair of onion grown in smutted soil.
Fig. 11. Microphotograph of T. S. onion leaf showing distribution of spore masses.
Fig. 12. T. S. onion leaf showing spore masses in intercellular spaces. × 400.
Fig. 13. L. S. onion leaf showing sporogenous hyphae and developing Chlamydospores. × 400.
Fig. 14. Branched haustorium in host cell. × 400.
Fig. 15. Developing Chlamydospore. × 1000.
Fig. 16. Developing Chlamydospore. × 2250.
Fig. 17. Developing Chlamydospore, investing hyphae becoming septate. × 2250.
Fig. 18. Young Chlamydospore showing nucleus and nucleolus. × 2250.

THE INHERITANCE OF DISEASE-RESISTANCE IN PLANTS*.

By F. T. Brooks, M.A.

Soon after the re-discovery of Mendel's law of inheritance in 1901, certain human diseases under suspicion of being transmitted hereditarily, were examined, chiefly from the statistical standpoint, by tracing the incidence of disease in families of known pedigree. In this way it was found that some of these maladies, such as colour-blindness and haemophilia, were transmitted from one generation to another essentially according to Mendel's law, notwithstanding certain complications which can now be explained. It is now known that these particular diseases are sex-linked, the mother transmitting the defect in obvious form to her sons and not to her daughters, in whom the disease is usually either absent or latent.

As regards plants, it has long been clear that some varieties

* Paper read at a meeting of the Association of Economic Biologists, September 1920.

of cultivated plants are much more susceptible to certain diseases than are others. To quote two well-known examples: the variety of potato known as "Up-to-date" is much more liable to attack by blight than is the variety "President," and in wheat "Michigan Bronze" is much more susceptible to yellow rust than is "Squarehead Master." The idea was then conceived by Biffen, that, in the case of certain plant diseases affecting closely related varieties, susceptibility and immunity might be a pair of allelomorphic characters segregating in Mendelian fashion. The work which has been done in this respect in recent years is chiefly due to Biffen and his co-workers. In consequence of their activities it is now clear that, in the broad sense, susceptibility and immunity as regards certain plant diseases can be looked upon as factors which, like many others, are transmissible in an hereditary manner according to known laws.

Much of the evidence at present available in this field concerns the Yellow Rust of wheat, *Puccinia glumarum* form *tritici*, the commonest wheat rust in this country and the one causing most harm in the aggregate.

Biffen (1) crossed certain very susceptible varieties of wheat with other highly resistant ones. The results of one of these crosses, that between the resistant "Rivet" and the susceptible "Red King" will be considered. The hybrid plants resulting from this cross, i.e. the F_1 generation, were found to be all as badly rusted as the susceptible parent. The flowers of these hybrids were then self-pollinated, and, in the resulting generation, roughly one quarter of the plants were highly resistant or immune, while the remainder were moderately or badly attacked by rust. On analogy with other Mendelian results it was most probable that the plants of the F_2 generation showing susceptibility to rust were of a mixed character, those carrying only the factor making for susceptibility to rust, i.e. in Mendelian phraseology, those homozygous to the factor of susceptibility, and those of mixed genetic constitution, the so-called heterozygotes carrying both factors, susceptibility and immunity, the former being dominant or masking the latter. The proof of the genetic constitution of the F_2 plants showing susceptibility to rust would have been shown in the F_3 generation, but unfortunately in this series of experiments the F_3 cultures suffered from various causes and the mortality was so high as to make the results inconclusive in some respects. It was obvious, however, that rust-free F_2 plants produced only rust-free plants in the next generation, and also, that some of the susceptible (F_2) plants gave rise to susceptible F_3 individuals only. There remained, nevertheless, some doubt as to the behaviour of the progeny of the susceptible F_2 plants as a whole, which has since

been cleared up by Armstrong—a co-worker of Biffen, and to whom I am much indebted for kindly allowing me to make use of his results for the purpose of this paper, before they are actually published. Biffen's results showed clearly, however, that resistance to Yellow Rust was inherited as a simple Mendelian recessive character.

Armstrong used the same scale indicating the intensity of rust attack on individual plants as that adopted previously by Biffen. Thus

0	indicated	a rust-free plant.
1	,,	slight attack.
2	,,	moderate attack.
3	,,	bad attack.
4	,,	very severe attack.

Such a scale can only indicate the relative extent of rust attack in a given season. In an exceptionally bad rust year such as 1919, plants placed in grade 3 may be as severely attacked as plants placed in grade 4 another year. It seems, however, to be the only practical method which can be used under field conditions where large numbers of plants have to be examined.

The varieties of wheat chosen for hybridisation by Armstrong were "Wilhelmina" and "American Club," the former being moderately susceptible and the latter highly resistant or immune to Yellow Rust. Both varieties by the way are susceptible to Brown Rust (*Puccinia triticina*) which, however, in Cambridgeshire usually appears on the plants at a much later date than Yellow Rust and does not interfere with observations made on the latter.

In 1916 the cross Wilhelmina ♀ × American Club ♂ was made. About 20 grains were obtained, and in 1917, all the plants arising from these grains were moderately rusted. These F_1 plants were allowed to self-pollinate themselves, and in 1918, of 829 F_2 plants sown in the autumn 627 became rusted, the remainder being rust free. This is a close approximation to the 3 : 1 Mendelian ratio. It should be pointed out that the plants were examined for rust at intervals during the season, the last inspection being made shortly before harvest. The whole F_2 generation—partly sown in the autumn and partly sown in the spring, contained 1560 plants of which 1213 finally were rusted and 347 were rust-free. In the spring-sown portion the proportion of completely rust-free individuals was considerably less than one-fourth of the total number, but on the other hand, the proportion of plants with only traces of rust—to which a special mark (*lx*) was given, was much higher than in the autumn-sown crop. If, in the whole culture, the badly-rusted plants (grades

3 and 4) be separated from those which were less severely attacked, the following totals are obtained:

Bad to severely attacked... ...	381 plants.
Moderately or slightly attacked ...	832 ,,
Rust-free	347 ,,

While these figures do not show a very close approximation to the 1 : 2 : 1 Mendelian ratio, the figures expected being 390, 780, and 390 respectively they are suggestive of it, and, as pointed out before, if the autumn-sown plants alone are taken into account, the correspondence is very close.

As regards the F_3 generation, considerations of time and space precluded cultures being raised from all the F_2 plants, so a number of the F_2 plants were selected so as to include individuals showing every degree of attack as well as a number which had remained rust-free. Altogether 198 plants were selected to provide the F_3 cultures. On account of a severe drought during May and June (1919) these F_3 cultures were top-dressed with nitrate of soda as it was feared that some of the plots would be ruined. One result of this application was that, almost without exception, the cultures were more severely rusted than their F_2 parents had been in the previous year. Furthermore, of the 69 cultures which gave evidence of segregation into badly-rusted and slightly-rusted individuals, very few plants remained actually rust-free. In addition, of the 17 cultures raised from F_2 plants which had been free from rust in 1918, in only two cultures did every plant remain absolutely rust-free in 1919. Notwithstanding these results, Armstrong points out that a comparison of these particular cultures with the homozygous susceptible ones growing alongside showed that the relative difference in the extent of rust attack was as great as had existed between their respective F_2 parents in the previous season. Armstrong concludes that, taking all the experimental evidence into account, and more especially the environmental conditions, these cultures were "genetically immune," but that the greater or less degree of predisposition to attack was due to the interaction of other causes or factors.

Of 12 cultures raised from F_2 plants showing only traces of attack, three proved highly resistant and were therefore probably homozygous "immune" cultures; the other nine cultures gave evidence of segregation into slightly, moderately, and badly rusted types, and were clearly the offspring of heterozygous plants.

Sixty-three cultures were raised from F_2 plants which had been moderately attacked. Fourteen of these proved homozygous susceptible cultures, for every plant became badly rusted. The remaining cultures gave evidence that they were the offspring of F_2 heterozygotes.

Of 19 cultures grown from F_2 plants which had been badly rusted in 1918, 15 proved to be homozygous susceptibles, and the others gave evidence of segregation.

The 24 cultures raised from very badly rusted F_2 plants all proved to be homozygous susceptibles.

In this generation, not only did the intensity of attack vary in the different cultures, but also the time of attack. Thus, in general, homozygous susceptibles were attacked earlier than heterozygous susceptibles and the latter were attacked earlier than the "genetically immune" where it happened that the last-named were attacked at all.

Taking the 56 cultures in which segregation in F_3 was clear, it was found that out of a total of 3045 plants, 2385 were either moderately or badly rusted, while 660 were only slightly rusted or not attacked at all. The 3 : 1 Mendelian ratio would be represented by 2284 : 761, and if it exists here, it follows that 101 plants out of a possible 761 recessives were rusted beyond the slight extent indicated by grade 1, i.e. 13·2 %. This degree of "disturbance in rust resistance," as Armstrong calls it, is comparable with that occurring in certain homozygous "immune" cultures of the same series in which 11 % of the plants were rusted beyond grade 1. This disturbance is attributed to the operation of environmental factors previously mentioned.

Seeing that a plant which shows traces of rust attack in one season may be shown by its offspring to have been "genetically immune" and that a rust-free plant in the F_2 generation may be actually an impure susceptible that has escaped infection, Armstrong realised the importance of applying the F_3 results to the statistics of the F_2 generation. In considering the F_2 results in these researches, it was seen that the 1 : 2 : 1 ratio was not closely reached, although it probably existed, as is shown by applying the results of the F_3 cultures to the F_2 statistics. In this way, the probable composition of the autumn-sown F_2 crop was:

202 (homozygous susceptibles) : 419 (heterozygous susceptibles) : 208 (homozygous immunes),

the expected numbers being 207 : 414 : 207.

Similarly, the estimated composition of the spring-sown part of the F_2 generation was 190 : 378 : 163, the expected numbers being 183 : 365 : 183. Taking the whole of the F_2 crop together after adjustment with the F_3 results, the following composition is indicated:

392 homozygous susceptible individuals.
797 heterozygous ,, ,,
371 homozygous immune ,,

These results appear to be conclusive and show that susceptibility and immunity to Yellow Rust can be considered to be genetic factors operating in a Mendelian way.

Resistance to Yellow Rust has thus been shown by Biffen and Armstrong to be a Mendelian recessive character. Resistance to Mildew (*Erysiphe graminis*) as regards wheat has been shown on the other hand by Armstrong to be a dominant character. Thus the variety Wilhelmina, which is very susceptible to mildew, on being crossed by the variety Persian which is immune to mildew, gave hybrids which were also completely immune to this disease. The F_2 generation of this cross grown during 1920 consisted of some 900 plants about 100 of which were attacked by mildew. The rest remained free from attack, but owing to the general weakness of many of the plants, the thinness of the crop, and other conditions unfavourable to mildew attack, Armstrong states that no accurate statistics are available. Further researches therefore are necessary to show how far resistance to mildew can be correlated with the mode of inheritance of resistance to Yellow Rust.

Little work has yet been done concerning the mode of inheritance of resistance to other plant diseases, but there is a wide field of research available here and one full of promise. Indications are to hand that resistance and susceptibility to wart disease of potatoes may be a pair of allelomorphic characters, the practical bearing of which is obvious.

The breeding of disease-resistant varieties of cultivated plants is clearly one of the most effective means of combating plant diseases of economic importance, and this method applied to cereals has already given results of considerable value.

In this connection, however, there are some considerations which must be taken into account, that tend to limit the universal application of the methods of the plant breeder to cure all the ills to which plants are subject. Immunity is a term covering many shades of meaning, and sometimes the so-called immunity to disease is merely the expression of the accidental escape of the host from coming into contact with the germs of the parasite that cause infection. Where immunity is really of the nature of active disease-resistance, the basis of immunity is probably very diverse in different diseases. Thus immunity to a malady such as wart disease of potatoes which is caused by an organism which can only live parasitically, i.e. is an obligate parasite, probably depends upon factors different from those conferring immunity to a wound parasite, where the fungus begins growing as a saprophyte prior to invading tissues consisting perhaps essentially of dead cells. There is as yet no information available as to the inheritance of disease-

resistance in plants affected by wound parasites. As regards plant diseases caused by obligate parasites such as wart disease of potatoes and rust in wheat, it seems necessary to distinguish between what is apparently absolute immunity and what is on the other hand a very high degree of resistance to disease. Now in the case of wart disease some varieties appear to be absolutely immune to this disease, and as far as I am aware, this immunity appears never to have broken down, though it would be hazardous to say that this will not be accomplished under experimental conditions. Rust-resistance in cereals on the other hand does not seem to be absolute in character, but to be influenced in part at any rate by the conditions of environment, including the physiological constitution of the host. Thus, Einkorn wheat, which under ordinary conditions is practically immune to attacks of rust fungi, has been shown by Howard (2) to lose its character of resistance to Black Rust under certain extreme climatic conditions (great heat) at Pusa in India. Again, the variety of wheat "Little Joss," which in the actively growing state is practically free from Yellow Rust during most years is sometimes found to be considerably rusted during the early part of the year. The results given in the earlier part of this paper illustrate the same or an allied phenomenon, for it was often found that plants—described as "genetically immune"—were affected to a slight extent by rust. The offspring of these slightly rusted plants might remain completely rust-free another year, the environmental factor which operated to reduce the resistance during the previous year being thus eliminated. It is clear therefore that although there is an hereditary factor as regards resistance to rust in some wheats, it is not impossible that the conditions of environment have the power of modifying the expression of the genetic factor. There is some evidence too that in wheats of hybrid origin, other factors such as the nature of the root system may themselves influence the general physiological constitution of the plant so as to modify somewhat its powers of resistance to disease. The plant breeder must, therefore, take into account the possibility that changed conditions of environment may break down to some extent the resistance-powers of the host as regards certain diseases, although it is likely that under average conditions of environment, the "genetic immunity" of the resistant variety will be able to hold its own. As is well known, excessive nitrogenous manuring sometimes increases the susceptibility to fungoid disease, and in this connection it is interesting to note that on the Cambridge University farm this year—May and June being very dry, nitrogenous manuring of the highly resistant wheat "American Club" and of the practically immune derivatives of

the cross between this and "Wilhelmina" seemed to have practically no effect as regards rendering them more susceptible to attacks of Yellow Rust. It seems that in these plants the genetic constitution was strong enough to be uninfluenced by a heavy application of nitrogenous manure.

Another consideration to be borne in mind by the plant breeder is that parasitic organisms are themselves plastic and liable to temporary or permanent change leading perhaps to the evolution of races which are more virulent than previous forms. The education of relatively harmless forms of bacteria to pronounced virulence is a well-known phenomenon, and the same may prove to be true of certain fungi, but there is yet little evidence of this. Indeed, evidence obtained by Stakman (3) in America points to the various races of *Puccinia graminis* being very stable forms with little power of adaptability. He has also found that there are several races of *Puccinia graminis* on wheat inhabiting different parts of the United States, so that a wheat resistant in one place is readily attacked at another because it is exposed to infection by another strain of the fungus. Facts of this kind necessarily complicate the problem of breeding disease-resistant varieties.

Notwithstanding these difficulties, which one may perhaps be allowed as a plant pathologist to place before the plant breeder, the latter will probably always be able to keep ahead of important changes in the resistance-power of the host, whether these be due to alterations in its constitution brought about by environmental factors or to increased virulence on the part of the parasite.

It is only in the case of Yellow Rust that we have anything like adequate knowledge of the inheritance of disease-resistance, and even here, we are very much in the dark as to what is the essential factor conferring resistance, although, from the researches of Marshall Ward and others, it is certainly of a subtle, protoplasmic nature. It is suggestive that in some immune wheats the fungus appears to be unable to attack the host with sufficient vigour to establish itself, while in others, the attack appears to be conducted with such violence as to defeat its own ends, the infecting hyphae being surrounded by so many dead host cells that the mycelium cannot penetrate to the living tissues in which alone the quasi-symbiotic life necessary for the rust fungus can be established.

BIBLIOGRAPHY.

(1) Biffen, R. H.—Studies in the inheritance of disease-resistance. Journ. Agric. Sci., 1907.
(2) Howard, A. and Howard, G.—Wheat in India, 1909.
(3) Stakman, E. C. and others.—Plasticity of biologic forms of *Puccinia graminis*. Journ. Agric. Research, 1918.

NOTES ON NEW OR RARE BRITISH FUNGI.

By Malcolm Wilson, D.Sc., F.L.S., F.R.S.E.
University of Edinburgh.

DASYSCYPHA CALYCIFORMIS (Willd.) Rehm.

On the trunk of *Picea excelsa* Link; collected by Dr A. W. Borthwick, Keir, Stirlingshire, March 1914, and by Mr J. M. Murray, near Peebles, December 1920.

This species, which has not been previously recorded in Britain, is a wound parasite causing cankers on the spruce similar to those produced by *D. calycina* Fuck. on the larch; it has also been described on *Abies pectinata* DC., *A. sibirica* Ledeb., *Larix europaea* DC., *Pinus sylvestris* L. and *P. Pumilio* Haenke on the continent. Although often occurring as a saprophyte it has been shown by Wagner (Zeits. f. Pflanzenkrankheiten, Bd. VI, 1896, p. 321) to be parasitic on the silver fir, and Zederbauer (Centralbl. f. d. gesamte Forstwesen, Heft 1, 1906) describes it as causing a serious disease of the spruce in Austria.

It closely resembles *D. subtilissima* Cke. but is distinguished from that species by the following characters:

D. subtilissima, asci 65–70 × 7–8 μ; ascospores slightly curved, 8–10 × 2 μ; paraphyses equal in length to the asci.

D. calyciformis, asci 50–60 × 4·5–5 μ; ascospores elliptic or spindle-shaped, straight, 5–7 × 2·5–3 μ; paraphyses longer than the asci.

The conidial fructifications which have been described by Schellenberg (Mitt. d. Schweiz. Zentralanst. f. d. forstl. Versuchsw. Bd. III, H. 3, 1905, p. 269) were abundant on one of the specimens. The pustules are whitish on the exterior, and are surmounted by the dull yellow mass of conidia; after washing away the conidia they are seen to be slightly cup-shaped with deep tortuous unfoldings of the surface so that in section they appear to be divided into a number of chambers; the conidia are about 3 × 1 μ and are borne terminally on simple conidiophores which form a continuous layer on the inner surface of the fructification. The suggestion made by Hartig (Bot. Centralbl. Bd. 37, p. 78, 1889) that *Phoma abietina* Hart. is the conidial stage of this species was only founded on the juxtaposition of the two fungi and appears to be incorrect.

HYPODERMA PINICOLA Brunch.

On the living leaves of *Pinus sylvestris* L., Glen Lochy, near Dalmally, Argyllshire. Collected by Dr A. W. Borthwick, September 1920.

Fructifications on both surfaces of the leaf, arranged in series, 1–2 mm. long, grey or yellowish-grey, continuously covered by the epidermis, opening by a long slit. Asci club-shaped, very shortly stalked or sessile, 120–170 × 15–20 μ. Spores 8, club-shaped, non-septate, guttulate, thickest at the rounded obtuse upper end and gradually diminishing to the acute lower end, very variable in size often curved, 42–100 × 3–5 μ surrounded by a layer of mucilage 3–5 μ in thickness. Paraphyses filiform, straight or slightly hooked. The fructifications, which may be occasionally more than 2 mm. long, are not at all obvious on the partially dried leaf. They are usually surrounded by an irregular area of brownish- or yellowish-grey dead tissue and the abundance of these areas gives the whole shoot a greyish tinge. The mycelium is abundant in the parenchyma just below the fructifications, but does not extend to the vascular strand and is generally confined to the side of the leaf bearing the fructifications; the hyphae are 3–5 μ in diam., colourless and provided with transverse dividing walls. The covering layer of the fructifications consists of pseudoparenchyma and is 4–6 cells in thickness; the uppermost layer immediately underneath the persistent epidermis is opaque and dark-coloured, the remaining cells having little colouring matter; the whole has a distinct violet tinge. Brunchorst gives no measurement of asci or spores in his description (Nogle norske skovsygdomme. Bergens Museums Aarbog, 1892), but his figure shows that the spores are about $\frac{1}{3}$ the length of the ascus and the length of the spore is about ten times its breadth at the thickest part. The spores in the Scottish specimens are usually longer than this but some agree in shape with Brunchorst's figure. Their size is very variable; generally in each ascus 3–4 spores are about $\frac{2}{3}$ of the length, 2–3 about $\frac{1}{2}$ the length and the remainder only about $\frac{1}{3}$ of the length of the ascus; they are more or less twisted round each other in the ascus. The spores usually escape by an almost transverse rupture towards the lower end of the ascus but sometimes by an apical opening.

Saccardo (Sylloge Fungorum, vol. XI, p. 389) questions whether the species ought not to be placed in the genus *Hypodermella* but the presence of only four spores in the ascus in the latter as well as the considerable resemblance between *Hypoderma pinicola* and *H. nervisequum* seems to negative this.

Lind (Danish Fungi, Copenhagen, 1913) considers that *Hypoderma pinicola* Brunch. is synonymous with *Hypodermella sulcigena* Link. By the courtesy of Prof. Ferdinandsen of Copenhagen it has been possible to examine Danish specimens of the latter species but these unfortunately do not bear ascigerous fructifications. The needles of *Pinus sylvestris* attacked

by *H. sulcigena* bear brownish-black blotches or zones which are considerably larger and darker than the diseased areas produced by *H. pinicola*. The darker colour of the former species is produced partly by the hyphae in the leaf tissue which are up to 6 μ in diameter and pale brown in colour and partly by the brownish discolouration of the leaf tissue, especially the hypoderma. In the description of *H. sulcigena* given by Rostrup (Undersogelser over Snyltesvampes Angreb paa Skovtraerne. P. E. Muller's Tidsskrift for Skovbrug, Bd. VI, 1883, p. 199. Ref. Bot. Centralbt. Bd. XV, 1883, p. 151), the measurements of the asci are given as 75–85 × 12 μ and the ascospores 30–40 × 4 μ; there are only four spores in each ascus. If these measurements are constant there are evidently considerable differences between the two species. In addition the mucilage surrounding the ascospores is stated to stain bright green with tincture of iodine in *H. sulcigena* while this is not the case in *H. pinicola*.

HYPODERMA BRACHYSPORUM (Rostr.), Tub.

On leaves of *Pinus Strobus* var. *nana*, Knight. Murthly, Perthshire, April 1920. Not previously recorded for Britain, but widespread on the continent.

PUCCINIA MILLEFOLII Fuck.

On *Achillea Millefolium* L., Epsom Common, September 1919.

PUCCINIA PAZSCHKEI Dietel.

On *Saxifraga longifolia* Lapeyr., *S. Hostii* Tausch. and its var. *rhaetica* and on *S. Aizoon* Jacq. var. *cultrata*, Royal Botanic Garden, Edinburgh, September 1920.

The sori are usually on the upper surface toward the apex of the leaf, occasionally on the under surface, rounded, up to 3 mm. diam.; a large sorus is often surrounded by a ring of small ones. At first the portion of the leaf around the sorus is yellowish; later on dark brown irregular patches of dead tissue are produced which extend through the thickness of the leaf. Teleutospores 32–38 × 17–20 μ. Previously recorded at Kew on *Saxifraga longifolia*, at Sutton Coldfield on the hybrid *S. Cotyledon* × *S. Aizoon* and in Switzerland and Austria on *S. Hostii*.

PUCCINIA GENTIANAE Link.

Teleutospores on *Gentiana verna* L. and *G. acaulis* L.; collected by Mr D. Hendry, Llanisten, near Cardiff, Oct. 1920.

This species has not been previously recorded on *G. verna* in Britain. Plants of *Gentiana asclepiadea* L. growing in close proximity were not diseased although this species is attacked on

the continent. This species has been previously recorded from Kew Gardens and Horsham.

PUCCINIA SEPTENTRIONALIS Juel.

Since the previous note (Journ. Bot. vol. LIII, 1915) the uredospores of this species have been found on Ben Lui on *Polygonum viviparum* L. and the teleutospores on the same host on Meall nan Ptarmachan; the aecidium on *Thalictrum alpinum* L. has also been collected on Ben Voirlich (Loch Lomond).

PUCCINIA DISPERSA Eriks. et Henn.

Aecidia on *Anchusa arvensis* Bieb. near Kidderminster, August 1912.

Uredospores on *Aira caespitosa* L. Ballinluig, Perthshire, August 1915.

The aecidia on *Anchusa* have been shown to be connected with the form on rye (*P. secalina*). The specimens were found in proximity to a field of rye.

The uredospore stage on *Aira caespitosa* has been recorded from a few localities in England by Grove (The British Rust Fungi, p. 265) but nothing appears to be known of its aecidial host or specialisation. Numerous capitate paraphyses are present among the uredospores.

PUCCINIA MOLINIAE Tul. (?)

Teleutospores on *Molinia caerulea* Moench. near Killin, Perthshire, September 1919.

Teleutospore sori amphigenous, black, elongated, up to 4 mm. long, pulvinate; spores ellipsoid, rounded at both ends, thickened above (up to 7 μ), very slightly constricted, smooth, yellow-brown, 32–44 × 19–29 μ, mostly 36 × 25 μ, pedicels hyaline, persistent up to 160 μ long; mesospores present.

A *Puccinia* on *Molinia caerulea* was collected by Buchanan White in Perthshire, but has not been definitely connected with any aecidium; it appears however to agree in teleutospore characters with *P. Moliniae* Tul.

The present specimens differ from those of Buchanan White principally in the greater thickness of the wall at the apex of the teleutospore. Rostrup (Bot. Tidsskrift, IV, 1874, pp. 10 and 237) in Denmark has shown that *Aecidium Orchidearum* Desm. on *Orchis latifolia* is the aecidial stage of *P. Moliniae* and Schröter has found this aecidium growing along with *P. Moliniae* in Silesia. As a result of Rostrup's work von Tavel (see Klebahn, Die wirtswechselnden Rostpilze, p. 97) has pointed out that *P. Moliniae* should be expected to occur in the plant association found in Switzerland described as "Besenriedwiese" by Stebler and Schröter in which both *Molinia caerulea* and *Orchis sp.*

are found. It is interesting to note that the Killin specimens were found in an association closely resembling this type and this suggests a possible relationship to *Aecidium Orchidearum*. Plowright and others however have been unable to confirm Rostrup's results. Juel (Mykologische Beiträge. III. Ofvers. Kongl. Vet.-Akad. Förh. No. 9, 1894, p. 503) in Norway has proved the connection of a *Puccinia* on *Molinia caerulea* with an aecidium on *Melampyrum pratense* and has given the name *P. nemoralis* to the species; in this the teleutospore wall is somewhat thinner than in *P. Moliniae* Tul. No aecidium on *Melampyrum* has been found in Britain.

Cruchet (Centralbl. f. Bakt. Bd. 17, Abt. II, 1906, p. 674) has described the species *P. Brunellarum-Moliniae* with its aecidial stage on *Brunella vulgaris* (*Aecidium Prunellae* Wint.) and in this species the wall at the apex of the teleutospore is thicker than that of *P. Moliniae* Tul. The specimens may therefore belong to this species and this suggestion is strengthened by the fact that *Aecidium Prunellae* has been recorded from Forres by Keith.

Cruchet considers that the three forms (*P. Moliniae* Tul., *P. nemoralis* Juel and *P. Brunellarum-Moliniae* Cruchet) can be distinguished by curves constructed from the teleutospore measurements, but the use of this method gave no definite indication as to the identity of the specimens. It is hoped to obtain more information on this point during the coming summer.

PUCCINIA ANTHOXANTHI Fuck.

On *Anthoxanthum odoratum* L., Meall nan Ptarmachan, Perthshire at altitudes between 2500–3000 feet, October 1919.

Only uredospores are present accompanied by numerous paraphyses. The sori are exclusively epiphyllous, rather larger and more conspicuous than usual, bright orange-yellow in colour, and seated upon rather conspicuous orange-yellow spots. Uredospores 25–28 μ.

Specimens with the usual characters, with uredospores and paraphyses have also been collected at Ballinluig, Perthshire, and on Mumbles Head, Glamorgan.

CRONARTIUM RIBICOLA F. de Waldh.

Aecidial stage on *Pinus monticola* Don, *P. Cembra* L. and *P. Lambertiana* Doug., Murthly, Perthshire, April 1920. This appears to be the first record on *Pinus Lambertiana* in this country.

MELAMPSORELLA CARYOPHYLLACEARUM Schröt.

Uredospore stage on *Stellaria Holostea* L., Ballinluig, Perthshire, April 1915. Only once previously recorded on this host in this country*.

* West Porlock and Horner Woods. Uredineae of West Somerset, by N. G. Hadden. Journ. of Bot. LVIII (1920), p. 39.

HAPALOSPHAERIA DEFORMANS Syd.

On the anthers of *Rubus fruticosus* L. near Aberlady, Haddingtonshire, 1904. Collected by Dr A. W. Borthwick.

This species was first described by Sydow in 1907 (Annales Mycologici, Bd. v, 1907, p. 398) from material collected in Thuringia, Germany, on *Rubus dumetorum*. At first only mycelium in and among the anthers and isolated spores were found and the fungus was accordingly placed in the genus *Paepalopsis* as *P. deformans*.

Later (Diedicke und Sydow, Annales Mycologici, Bd. vi, 1908, p. 301) the examination of additional material showed that the spores were produced in pycnidia and *Hapalosphaeria*, a new genus of the Sphaeropsidales, was constituted for its reception.

The fungus produces a growth on the *Rubus* resembling a witches' broom. The infected flowers are recognisable in the bud by the enlargement of the sepals, the apices of one or more of these being elongated and sharply recurved. Numerous, small, rounded or conical pycnidia are produced in the outer wall of the anther which open on the surface. The pycnidia are light brown in colour, 50–80 μ in diam.; the wall consists of many layers of small thin-walled cells. The spores are hyaline, spherical, smooth, 3–5 μ in diam. and are budded off from elongated conical cells on the inner side of the wall.

The Scottish specimens generally agree in structure with the above account, but no unusual growth was observed on the bush and no mycelium is present between the anthers; hyphae are however present in abundance in the anther walls and cavities.

MELASMIA EMPETRI Magn.

On the stem of *Empetrum nigrum* L., Creag na Caillich near Killin, Perthshire, altitude 1500 ft., Sept. 1919, and Peaks of the Castles, Arran, altitude 2500 ft., May 1920.

In the specimens collected in the autumn the fructifications were unopened and the conidia immature; in those found in the spring the stomata were split longitudinally and the conidia projected slightly as a pinkish mass. Diseased plants are recognisable on account of the abnormally elongated twigs bearing smaller leaves than usual which become yellow early in autumn.

Magnus, who discovered this species in the island of Wollin, Germany (Berichte d. d. bot. Ges. Bd. iv, 1886, p. 104) supposed that it might be the conidial form of a species of *Rhytisma* and expected to find asci developed in over-wintered specimens but was unable to find spores of any kind on diseased plants in the spring.

The specimens from Arran collected in the spring show typical *Melasmia* conidia similar to those described by Magnus and no trace of asci and it is evident that *Melasmia Empetri* has no connection with any species of *Rhytisma*.

There is little doubt that *Rhytisma Empetri* Buchanan White is identical with *Melasmia Empetri* Magn. In the description of White's specimens given by Berkeley and Broome (Annals and Mag. of Nat. Hist. vol. XVII, 1876, p. 129) no mention is made of the spores but the asci are described as straight and immature; these were probably the sporophores. Three specimens of *Rhytisma Empetri* collected by White are preserved in the Kew Herbarium but these are sterile and contain only sporophores of the *Melasmia* type. There is one specimen in the British Museum herbarium collected by D. Hay probably in Perthshire and named apparently by Broome but this contains no asci. Mr D. A. Boyd informs me that he has collected specimens of *R. Empetri* White near Largs, Ayrshire, and also from Creag na Caillich, but has never found asci developed in them. The late Prof. Trail considered that *R. Empetri* White might be the same as *M. Empetri* Magn. (Scot. Nat. vol. II, n.s. 1881–1888, p. 235). Juel, who has recorded *Melasmia Empetri* Magn. in Sweden (Mykologische Beiträge. II. Ofvers. Kongl. Vet.-Akad. Förh. No. 9, 1894, p. 502) points out that it resembles *Rhytisma Empetri* White fairly well in external appearance. Stevenson (Mycologia Scotica) states that *R. Empetri* White is found in the Tay, Dee, and Moray areas and at Inverness, Rannoch, Braemar and N. Wales. White records it as common in Breadalbane, Athole and Rannoch. No further information regarding its occurrence in N. Wales has been found.

Rhytisma Empetri Fr. (*Duplicaria Empetri* Fuck.) is a different species and has not been recorded as British.

Botrytis Douglasii Tub.

On living shoots of *Pseudotsuga Douglasii* Carr., Murthly, Perthshire; on seedlings of *Pseudotsuga Douglasii* Carr. near Forfar, and on seedlings of *Larix leptolepis* Endl. near Edinburgh. Collected by Mr J. M. Murray, October 1920. This has been shown by Behrens to be identical with *Botrytis cinerea* Pers.; it does not appear to have been recorded previously on these hosts in this country.

I wish to record my thanks to Prof. Ferdinandsen of Copenhagen for specimens of *Hypodermella sulcigena* and the Director of the Royal Gardens, Kew, Mr D. A. Boyd, and especially Mr J. Ramsbottom of the British Museum (Natural History) for information regarding several of the above species.

NOTES.

AUDIBILITY OF THE SPORE DISCHARGE IN OTIDEA LEPORINA.

On the visit of the Cryptogamic Society of Scotland to Perth, in September 1920, *Otidea leporina* was found in abundance, and I brought away half-a-dozen mature specimens to Glasgow. They were packed in a box, each one wrapped in paper, and they remained there twenty-four hours.

On opening the box the specimens were placed on the table, and I attended to something else. While thus engaged I heard every now and then a slight hissing sound, but, being busy, paid no attention to it, till looking by chance at the table I saw one of the Otideae puff, and immediately heard a hiss. The hiss was quite distinct, and required no effort to hear it, although I was fully six feet from the plants. Mr Stone's experience as recorded in the Transactions, vol. VI, p. 294, occurred to me, and placing my six specimens in a row I sat for some time watching my miniature field battery at work. First one fired (puffed), followed by the report (hiss), then another carried on, the others following in their turn at intervals of not more than two or three minutes. I noticed as the time passed that the intervals between the puffs increased in length.

What surprised me was the frequency with which they puffed, but as I was preparing for a journey to the south of England I had to put the specimens away without having noted the length of the intervals between the puffs, the length of time they retained the power of puffing, or the extreme distance at which the hiss could be heard. These points, however, will form material for future investigation.

R. B. JOHNSTONE.

CALIFORNIAN BEES.

During the past two years queries have been repeatedly received concerning the identity of what has been variously called "Californian Bees," "Palestine (or Jerusalem) Bees," "Macedonian (or Salonika) Bees," "Mesopotamian Bees," "Belgian Bees," "Egyptian Bees," "Wine Bees," "Water Bees," "Balm of Gilead," etc. This consists of solid, white, semi-translucent lumps usually about the size of peas and looks somewhat like pieces of soaked sago or tapioca. It is cultivated in sugar solution to which syrup is sometimes added and gives rise by fermentation to what is often called "Bee wine." The lumps move in the solution, the

buoyant dancing being due to the copious evolution of gas bubbles from their surfaces. It is probably this movement that has led to their being called "Bees."

The organism is the well-known Ginger-beer plant which was investigated by the late Professor Marshall Ward*. As the lumps move they shed yeast cells all round which increase and form a deposit at the bottom of the containing vessel: the liquid becomes viscous with slimy masses in it. Ward found that two organisms constitute the ginger-beer plant proper – a yeast, *Saccharomyces pyriformis* and a bacterium, *Bacterium vermiforme*: both are necessary for its formation and peculiar action. Other organisms can be grown out of both the lumps and the liquid but these are merely accessory or foreign organisms such as one would expect to find in a sugar solution exposed to the air. Ward reconstituted the ginger-beer plant by bringing together pure cultures of the yeast and the bacterium and showed that the specimens so produced acted like the original material. He regarded the relation between the two species as one of symbiosis. "The Schizomycete is favoured by obtaining some substance or substances directly they leave the sphere of metabolic activity of the yeast-cells; it can benefit by the presence of these substances even apart from the living yeast, though to a less extent.

The yeast, on the other hand, benefits by these substances being removed and destroyed, hence its renewed and continued activity—as evinced by the steady and copious evolution of carbon dioxide for weeks, and the corresponding increase of the yeast-cells by budding—when the symbiosis is established."

The origin of the plant is unknown. Ward obtained a certain amount of evidence showing that "the yeast (*Saccharomyces pyriformis*) is introduced from the grocers' shops attached to the ginger and brown sugar employed in ordinary practice, while the bacterium (*B. vermiforme*) is introduced with the ginger." That there was an "epidemic" similar to the present one about forty years ago is seen from the following note (*Gardeners' Chron.* XXI (1884), p. 542), by the late Mr Worthington G. Smith.

"The Editor of the *Gardeners' Chronicle* has several times been requisitioned by correspondents (mostly anonymous) for a scientific description of the 'Ginger Beer Plant.' The correspondents want to know its botanical name and native country. The writer of this note has also been tormented weekly, almost daily, on the same subject for two or three years. Every one has been asking him for the 'regular Latin or Greek name' of the 'Ginger Beer Plant.'

* The Ginger-Beer Plant, and the Organisms composing it: a Contribution to the Study of Fermentation-Yeasts and Bacteria. Phil. Trans. Roy. Soc. ser. B. CLXXXIII, pp. 125–197 (1893).

"Benevolent old ladies, clergymen and officers of the Blue Ribbon Army have called upon him, or written for a scientific explanation, hoping to make the 'Ginger Beer Plant' a boon for the poor. One person wished to feed paupers with it; another hoped by its means to knock all the publicans on the head; a third to send it in barrels for the army in the Soudan. When such persons have been told it is merely a form of German yeast they have turned away disappointed and disgusted. Something more must evidently be done for this rum shrub, of which I have recently had applications for slips, rooted cuttings, and seeds.... As all the correspondents insist on this 'American plant' being a new species I propose to humour them by calling it *Zingibeerophora spumacephala*."

Prof. Bayley Balfour exhibited the Ginger-beer plant at the Linnean Society in 1887. His statement—"it is said the Ginger-beer Plant was introduced into Britain by soldiers from the Crimea, in 1855"—is very interesting in connection with the modern names all excepting California being associated with our overseas armies, and many of the individual specimens having a story of a soldier connected with them in some way. From W. G. Smith's note quoted above it is apparent that the plant has been known in America for a number of years. It may be that it has commercial possibilities in that country on account of its fermentative properties. One interesting point is that in no case that has come to my notice has the ginger been added to the solution as in former days.

The method usually employed by English villagers for the making of ginger-beer is as follows*: "They make a solution of sugar corresponding roughly to a 10–20 per cent. solution in tap water, in a large open vessel, a little cream of tartar and a few pieces of ginger are then added; some add lemon as well. The pieces of Ginger-beer plant are then placed in the mixture, and the whole allowed to stand for a day or two. Then the liquor is poured off into bottles and corked, and is drunk after two or three days more. Meanwhile more sugar solution is exposed in the original vessel containing the deposit, or 'lees,' and allowed to stand and bottled off as before."

J. RAMSBOTTOM.

* H. M. Ward, *Loc. cit.* p. 129.

STUDIES IN ENTOMOGENOUS FUNGI.

With Plates III—V*.

I. THE NECTRIAE PARASITIC ON SCALE INSECTS.

By T. Petch, B.A., B.Sc.

Among the fungi known to develop on scale insects, the *Nectriae* occupy the first place from the historical point of view, a conidial stage belonging to this group having been described as growing on a coccus in 1848; while during recent years they have become the species most generally employed in the numerous attempts to control scale insects by means of entomogenous fungi. The present account deals with them from the systematic standpoint, and is the outcome of an examination of a number of collections from different countries which have come into my possession during the last fifteen years, as well as of the specimens in the Herbaria of the Royal Botanic Gardens, Kew, and the British Museum (Natural History).

My thanks are due to Mr E. E. Green, the well-known authority on Coccidae, for much of the available material from Ceylon and elsewhere, including part of the specimens examined and described by Parkin; to Mr H. S. Fawcett for material from Florida; Mr F. W. South, for specimens from the West Indies; Dr E. J. Butler, for specimens from India; Mr C. C. Brittlebank, for specimens from Australia; Prof. Ito, for specimens from Japan and Formosa; and Dr C. Spegazzini for specimens from South America.

I must also offer my apologies to the gentlemen named for the delay in dealing with the specimens they had so readily contributed.

Historical.

The earliest record of any fungus of this group on a coccid was made by Desmazières in 1848. Specimens of a conidial fungus, which appeared on scale insects on willows and ash trees in the winter months at Caen (Cadonum), France, had been sent him by one of his correspondents, M. Roberge, and for these he instituted a new genus, *Microcera*, with the species *Microcera coccophila*.

Desmazières' generic description is "*Microcera* Desmaz., nov. gen. Velum externum persistens, membranaceo-floccosum, dein supra in lacinias plures rumpens; receptaculum clavatum, carnosum, e fibris subsimplicibus sporidiiferis formatum; sporidia fusiformia, arcuata."

* The Plates will accompany the continuation of this article in the next Part of the Transactions.

The specific description is "*Microcera coccophila* Desmaz. Minutissima, subcaespitosa, cornuto-conica, simplex, lateritio-rosea, basi membrana tenuissima albida vaginato-connata. Sporidiis paucis hyalinis, elongatis, utrinque acutis. Hab., in Coccis, Hieme."

Desmazières was so struck by the singular formation and habitat of the fungus that he gave a further extended account of it. In this he was somewhat unfortunate, as it is chiefly this amplification which has led to doubt concerning the identity of his species, and to the inclusion in his genus of forms which have only little relation to it. The following details are taken from his account.

The fungus occurs at the margin of the scale. It appears first as a small horn, sometimes cylindric and obtuse, but most often attenuated from the base to a pointed apex. Each scale produces from one to three horns, but it is not rare to find scales from which arise five or six horns, apparently almost recumbent on the stem of the plant and forming a sort of star. The horns arise from a narrow stroma which runs beneath the margin of the scale, and the growth of this stroma inwards towards the centre ultimately forces off the scale and forms a tubercular mass which unites the bases of the horns. The horns are divergent, and scarcely half a millimetre high. Each is at first enveloped in a white sheath, very thin and membranous, which makes it appear flesh-coloured. This sheath is soon pierced at the apex, and the horn emerges in the form of a small cone, of a dark rose colour, generally with an acute apex which is sometimes curved into a hook. In that state, the persistent sheath, at the base of the little fungus, forms, as it were, a closely adherent volva, the margin of which is fringed. The horn appears fleshy, but is composed, like the sheath, entirely of hyaline filaments, almost simple, obscurely septate, very long, and scarcely 2·5 μ broad. The spores occur among these filaments, few in number, but large, hyaline, fusiform, pointed, and arcuate. The longest are about 100 μ long, with a breadth scarcely double that of the filaments. Frequently, several globules, somewhat equally spaced, occupy the central part of the spore, but septa have not been clearly distinguished.

Desmazières summarised as follows: "In the presence of a velum or volva, this minute production has, to some extent, the nature of a phalloid; in its habitat and fibrillose structure it bears some resemblance to the entomogenous Isarias provided with superficial basidia; and, finally, by its texture, its fibrils or filaments, and the shape of its spores, it is allied to the *Tuberculariaceae*, near *Fusarium*, and to the genus *Ditiola* which is provided with a membranous, evanescent covering or velum."

Desmazières' fungus was next described by the Tulasnes, in

Selecta Fungorum Carpologia, vol. I, p. 130, and vol. III, p. 105. They examined Desmazières' specimens, Plantae Crypt. Gallicae, ed. altera, fasc. XXVII, Nos. 1350 and 1750, and, in the approved modern fashion, had obtained specimens from the type locality. With these they correlated specimens from Florence, on *Laurus nobilis*, which exhibited both the conidial and the perithecial stages. The latter had been issued by Rabenhorst in Herbarium Mycologicum (Ser. nova, t. III (1860), Nos. 262 and 269) as *Nectria episphaeria* Tode and *Microcera coccophila* Desm. respectively. The type locality for the perithecial fungus is therefore Florence, not France as usually stated.

The Tulasnes' description may be summarised as follows. The fungus produces beneath the scale a pallid, or pale rose, fleshy stroma, paler and sparingly byssoid at the edge, which emerges and forms a narrow unequal margin round it. From this there arises a simple, thick, obtuse clava, about a line high. There is usually only one clava, rarely several. The apex is more deeply coloured, red, and bears, in a compact mass, curved linear-lanceolate conidia, 65 × 6·5 μ, three to five septate, borne singly on slender conidiophores. The perithecia appear later, at the base of the clava, or on the margin of the stroma, the clavae being wanting or aborted; they are small, globose, obtusely and very shortly papillate, sessile, very smooth, shining red, fleshy and fragile, in groups of three to five, somewhat collapsed when old. The asci are linear-cylindric, 60–80 × 6·5 μ, obtuse, subsessile, eight-spored, thin-walled; paraphyses are lacking (paraphyses vulgo quasi omnino desiderantur); the spores are smooth, muticate, subhyaline, often obliquely monostichous, ovate, straight, 10 × 5 μ, equally medially septate, and somewhat constricted.

It was noted that in Roberge's specimens from Caen several clavae might arise from the edge of the same scale, but in the specimens from Florence the conidial stage was much rarer.

The Tulasnes placed the fungus in their genus *Sphaerostilbe*, as it had a *Nectria* perithecial stage and a Stilboid conidial form. They stated that the Roberge specimens exhibited clavae which exactly resembled the true *Stilbum* of Tode, and added that the clava of *Microcera* imitated exactly *Stilbum flammeum* Berk. (*Atractium flammeum* Berk. and Rav.), in its form and the slenderness of its filaments, which were united by short isthmuses (ladder connections) and separated into a few straight branches. In their earlier note, they say that *Microcera* differs little from *Atractium*.

For the Tulasnes, then, *Microcera* was a *Stilbum* with long curved *Fusarium* spores. They were somewhat scornful of Desmazières' velum and his comparison with the phalloids,

stating that, whatever appearance of a veil there was, was due to a covering of white adpressed mycelium over the basal stroma, and no true volva was present. This immediately suggests a doubt whether they were dealing with the same fungus, for *Microcera* has the structure described by Desmazières, by whatever name one may call it.

There can, however, be no doubt that the *Microcera* of Desmazières is the *Sphaerostilbe* (conidial stage) of the Tulasnes. Yet one is loth to believe that such acute observers could have overlooked a feature which had been so strongly emphasised in a previous description. The probable explanation is that they were misled by Desmazières' unhappy comparison to a phalloid, and sought for a velum, or volva, surrounding the base of the stem of the Stilboid form: this supposition would appear to be supported by their statement that the apparent volva is merely mycelium on the surface of the stroma. But Desmazières' "velum" consists of the outer layer of the erect parallel hyphae which form the synnema; these are adherent to, or form the outer layer of, the stalk, but they do not terminate above in conidiophores, but in a series of teeth just below the head. They constitute a closely adherent sheath divided above into several narrow teeth which sometimes separate into a fringe of hyphae.

The next record of a *Nectria* on scale insects was made by Berkeley and Broome in their Fungi of Ceylon, No. 1028 (1873). They described there a species, as "*Nectria aurantiicola* B. and Br. Peritheciis aurantiacis in stromate erecto sitis; ascis clavatis; sporidiis ellipticis uniseptatis, sporisque fusuloideis (Thwaites, 190). On orange twigs. Ascospores 15 μ long, 7·5 μ wide; conidia fusiform, curved, multiseptate, 90 μ long; others triseptate and strongly curved, 20 μ long. Apparently growing from some Coccus." They gave figures of "a barren plant"; a stilboid synnema, bearing perithecia on the stalk; asci and ascospores; "flocci with fusiform conidia"; and a single long conidium. In 1875, Berkeley and Curtis described *Nectria aglaothele*, which grew on the remains of a coccus on alder in New England.

About 1886, Spegazzini described a new species of *Nectria*, growing on a coccus on fallen leaves, from Brazil, as *Nectria coccorum*; and a few years later (1889), another species, on a coccus on living leaves of a *Eugenia*, from the same country, as *Nectria coccogena*. No conidial stage was recorded for either.

In 1886, Ellis and Everhart described *Ophionectria coccicola* from Florida.

The number of conidial forms was increased in 1887 by the description of *Microcera rectispora* Cke. and Mass. This had

been sent by Bailey from Brisbane, Queensland. In the Handbook of Australian Fungi, Cooke gave figures of the conidia. It grew on "Coccus of the orange."

In 1892, Cooke enumerated and briefly described some of the foregoing species in his Vegetable Wasps and Plant Worms. Of *Microcera rectispora* Cke. and Mass., he stated, "In appearance it differs so little from the European species that, apart from the fructification (*sic*), they would be regarded as the same. So much importance has of late years been given to minute differences in spores that new species have become inevitable. In this instance, the spores are quite straight and spindle-shaped, acute at both ends, with about seven septa, and 150–200 × 10 μ." Cooke's figures suggest the conidial stage of *Ophionectria coccicola*.

In the same year, Ellis and Everhart published their North American Pyrenomycetes. In it they included *Sphaerostilbe coccophila* Tul., stating that specimens had been found on *Alnus serrulata* in Pennsylvania. Their description is practically that of Tulasne. They added "the conidial stage (*Microcera coccophila* Desm.) which has been sent from Florida by Dr Martin, and collected in Carolina by Ravenel (F. Am. 286) has stroma arising from various species of bark lice. It is red, obtuse, and about 2 mm. high. The conidia are linear-lanceolate, 5–7 septate, and 56–65 × 5–6 μ, nearly hyaline."

In 1897, Rolfs reported *Sphaerostilbe coccophila* as a parasite of the San José Scale, *Aspidiotus perniciosus*, in Florida, and inaugurated the use of the fungus as a means of combating that pest. From Rolf's figures, it would appear that he had *Sphaerostilbe coccophila*, or a species closely allied, though later workers in Florida have undoubtedly confused two totally distinct forms.

McAlpine, in 1899, included descriptions of *Microcera rectispora* Cke. and Mass. and *Microcera coccophila* Desm. in his Fungus diseases of Citrus trees in Australia. His description of the former is that of Cooke and Massee. There does not appear to have been any but the type collection of this species; McAlpine cites Bailey's gathering, and adds that it was on *Chionaspis citri*. In the same publication, McAlpine described *Fusarium epicoccum*, on Red Scale on Mandarin orange.

In 1901, Nomura published a paper on the Scarlet fungus disease of Scale insects in Japan. As this was written in Japanese, it had been overlooked by later writers until Miyabe and Sawada drew attention to it. Nomura stated that the sporodochia of his species were not stilboid, but irregularly-shaped protuberances of the *Tubercularia* type; and, after comparison with the figures of *Sphaerostilbe coccophila* given by

Rolfs, he came to the conclusion that his species was identical with that from Florida, but that both were distinct from *Sphaerostilbe coccophila* Tul. He named his species *Nectria coccophila*, and gave the dimensions of the ascospores as 15–20 × 5–6 μ. It occurred on *Aspidiotus perniciosus* and *Diaspis pentagona*.

In the same year, Zimmermann published an account of the fungi parasitic on scale insects in Java. He described a *Nectria* with a stilboid synnema, which he named *Nectria coccidophthora*, distinguishing it from *Nectria aurantiicola* B. and Br. by its colour and the form of the synnemata. It occurred on *Mytilaspis* sp. and *Parlatoria zizyphi*. In addition, Zimmermann recorded and figured *Ophionectria coccicola*, and described two other new species, *Lisea Parlatoriae* on *Parlatoria zizyphi*, and *Broomella Ichnaspidis* on *Ichnaspis filiformis*.

In 1902, Hennings instituted a new genus *Tetracrium* for a conidial fungus found in company with scale insects on orange leaves, in Brazil, the species being named *Tetracrium Aurantii*. This specimen was re-examined by von Höhnel in 1911, and found to be identical in structure with the conidial stage of *Ophionectria coccicola*. Von Höhnel also found on the type specimen perithecia which he regarded as belonging to the genus *Puttemansia* Henn.; he named these *Puttemansia Aurantii*, and made corresponding alterations in the nomenclature of the North American species.

In 1903 Hennings described a new species of *Fusarium*, *Fusarium coccidicola*, on a coccid on tea in German East Africa.

In 1904, McAlpine added two new species of *Microcera*, *Microcera tasmaniensis* on *Aspidiotus* on *Eucalyptus*, and *Microcera Mytilaspis* on a scale on *Hymenanthera dentata*, and gave figures of both species.

Parkin, in 1906, published a general account of the fungi parasitic on scale insects, and gave descriptions of a number of forms, collected in Ceylon and elsewhere. He referred the Ceylon Nectrias to *Nectria coccidophthora*, although there was a previous Ceylon record, viz. that of *Nectria aurantiicola*. The chief merit of his paper, as far as the present group is concerned, is that he recognised that there are two quite different conidial forms, appertaining to the *Nectriae*, common on scale insects in the tropics. But he assigned the *Microcera* form to *Fusarium*, and the other to *Microcera*. Parkin also refers to a *Calonectria*, found on *Chionaspis vitis* and *Mytilaspis citricola* in Ceylon.

In 1907, Trabut described *Microcera Parlatoriae*, found on *Parlatoria zizyphi* on orange at Algiers.

In 1908, Fawcett summarised the records of "*Sphaerostilbe coccophila*," and gave details of its structure, in a paper en-

titled "Fungi parasitic on *Aleyrodes Citri*." He also described a new species of "*Microcera*," but did not name it.

In 1909, Saccardo added a new European species of *Microcera*, *M. curta*, from Germany; and, in 1912, Patouillard described *Microcera Tonduzii* from Costa Rica.

Miyabe and Sawada gave an account of the fungi parasitic on scale insects in Formosa in 1913. They referred the common Japanese species to *Sphaerostilbe coccophila*, with considerable doubt. A *Microcera* which belongs to Parkin's second group was named *Microcera Fujikuroi*. *Ophionectria coccicola* was recorded, and a new species, *Ophionectria tetraspora*, was described.

Sawada subsequently (1914) published, in Japanese, a paper on "Some Remarkable Parasitic Fungi on Insects found in Japan." The only species mentioned which is relevant to the present subject is a new species of *Fusarium*, *Fusarium Aspidioti*, on *Aspidiotus perniciosus*.

In 1913, H. and P. Sydow instituted a new genus of *Sphaeriaceae*, *Coccidophthora*, parasitic on scale insects, on a specimen collected by Hara in Japan, the species being named *Coccidophthora variabilis*. In the following year, however, Hara stated that the specimen submitted to Sydow consisted of two fungi, a *Nectria* parasitic on a scale insect, and another ascigerous fungus parasitic on the *Nectria*. Hara named the *Nectria*, *N. variabilis*, and instituted a new genus for the super-parasite, which he named *Philonectria variabilis*.

In 1914, H. and S. Sydow described *Microcera Merrillii* on a scale insect from the Philippines.

Stevenson, in 1917, described a *Tubercularia* on *Lepidosaphes beckii* and *Hemichionaspis minor*, on Citrus in Porto Rico, as *Tubercularia coccicola*.

The species of *Nectriae*, or their probable conidial stages, which have been recorded as occurring on scale insects are:

Sphaerostilbe coccophila (Desm.) Tul. (1861).
Nectria aurantiicola B. and Br. (1873).
Nectria aglaothele B. and C. (1875).
Nectria coccorum Speg. (? 1886).
Nectria coccogena Speg. (1889).
Nectria coccophila Nomura (1901).
Nectria coccidophthora Zimm. (1901).
Nectria variabilis Hara (1914).
Ophionectria coccicola Ellis and Everhart (1886).
Ophionectria tetraspora Miyabe and Sawada (1913).
Puttemansia Aurantii von Höhnel (1911).
Scleroderris gigaspora Massee (1910).
Lisea Parlatoriae Zimm. (1901).
Broomella Ichnaspidis Zimm. (1901).
Microcera coccophila Desm. (1848).
Microcera rectispora Cke. and Mass. (1887).
Microcera tasmaniensis McAlp. (1904).
Microcera Mytilaspis McAlp. (1904).
Microcera Parlatoriae Trabut (1907).
Microcera curta Sacc. (1909).
Microcera Tonduzii Pat. (1912).
Microcera Fujikuroi Miyabe and Sawada (1913).
Microcera Merrillii Syd. (1914).
Microcera sp. Fawcett (1908).
Tetracrium Aurantii P. Henn. (1902).
Fusarium epicoccum McAlp. (1899).
Fusarium coccidicola P. Henn. (1903).
Fusarium Aspidioti Sawada (1914).
Tubercularia coccicola Stevenson (1917).

Of the twenty-nine species enumerated in the foregoing list, only nine are prior to the current century. The idea that fungi might be parasitic on scale insects and not on the plants on which they occurred appears to have spread very slowly, and, where the scale insect was not immediately evident, such species have been described without reference to their real host. Though the list is no doubt still incomplete, an examination of the species of *Nectria, Sphaerostilbe, Fusarium, Atractium* and *Microcera* in Herb. Kew and Herb. British Museum has shown that the following species are parasitic on scale insects.

Nectria diploa B. and C. (1868).
Nectria laeticolor B. and C. (1868).
Nectria subcoccinea Sacc. and Ellis (1882).
Nectria Passeriniana Cooke (1884).
Nectria oidioides Speg., *myrticola* Rehm.
Sphaerostilbe flammea Tul. (1861).
Atractium flammeum Berk. and Rav. (1854).
Fusarium coccinellum (Kalch.) Thuem. (1876).
Microcera pluriseptata Cke. and Massee (1888).

The following new species are described in this account:

Nectria Tuberculariae.
Nectria barbata.
Calonectria coccidophaga.
Podonectria echinata.
Patouillardiella Aleyrodis.
Fusarium Aleyrodis.

MICROCERA.

Desmazières described *Microcera* as clavate, composed of almost simple hyphae, and furnished with an external sheath, which is toothed at the apex. In his note, he stated that the sheath is closely adherent. The spores are fusiform and arcuate.

The Tulasnes overlooked the presence of the sheath, or if they saw it, did not understand that it was Desmazières' velum or volva. They stated that *Microcera* differed little from *Atractium*, and that some specimens matched the true *Stilbum* of Tode. From their remarks, and the inclusion of the fungus in the genus *Sphaerostilbe*, it is clear that they regarded *Microcera* as composed of parallel hyphae, like the usual *Stilbum*.

The fructification of *Microcera*, therefore, is a synnema, with *Fusarium*-like spores.

The generic descriptions of *Microcera* in the various text-books of mycology have carried on Desmazières' statement concerning the velum, but the fungus has been included in the *Tuberculariaceae*, whereas, in its fully-developed form, it belongs to the *Stilbaceae*. In actual practice, however, any fungus with fusarioid spores, which grew on a scale insect, has been assigned to *Microcera*.

One cannot examine many collections of fungi on scale insects from the tropics without noting that there are at least two distinct forms of conidial fungi, which have fusarioid spores. Parkin appears to have been the first to notice that. He de-

scribed the synnema of "*Nectria coccidophthora*" as having a closely adherent sheath, and that of the other form as having a loose sheath. But Parkin assigned the first, which is the true *Microcera*, to *Fusarium*, and called the second, *Microcera*. As he stated, the two forms are readily distinguished by the naked eye.

Sphaerostilbe flammea, *Nectria lacticolor*, *Nectria aurantiicola*, *Nectria subcoccinea*, *Nectria aglaothele*, and *Nectria coccidophthora* have the *Microcera* conidial fructification, and must all be classed as *Sphaerostilbe*. The second type of conidial fructification will be described as *Pseudomicrocera*; the only *Nectria* yet known to have this conidial stage is *Nectria diploa* B. and C.

The following description of *Microcera* has been drawn up principally from the tropical forms. Specimens from temperate countries, although their perithecial stages prove that they are the same species as those of the tropics, are usually so poorly developed that their structure can be ascertained only with considerable difficulty, and they must be regarded as depauperate examples of the tropical species. It is somewhat surprising that Desmazières recognised the real structure of *Microcera* from specimens collected in Europe, but it would appear from his account that he had a series of living specimens in various stages of development.

Fully developed specimens of *Microcera* (Plate III, fig. 1) are up to 2·5 mm. high, distinctly stilboid, with a stout terete stalk and an ovoid, subglobose, or flattened globose head. Smaller specimens may be clavate, expanding gradually upwards into the head (Plate III, fig. 8). The stalk is composed of parallel hyphae, which separate above and form the conidiophores. The latter give off branches repeatedly, at an acute angle, either alternately or unilaterally, the ultimate branches being usually very long. When the head is teased out, it separates into long brush-like pencils, each consisting of an original conidiophore with all its long branches.

The outer layer of the stalk hyphae do not separate to form conidiophores. They are united to one another laterally, and form a sheath, closely adherent to the stalk, which divides into long triangular teeth at the level of the head. The teeth do not recurve, but remain adherent to the head, and it is necessary to tease out the head in order to see them clearly. In small, or young, examples, the teeth extend almost to the apex of the head, but in larger examples they terminate some little distance below, along the side of the head, or even just above its base. Desmazières' account of the growth of the fungus appears to be correct. When the conidia have been dispersed the teeth may

converge, and form a pointed tip at the apex of the stalk (Plate III, fig. 5). In some instances, there are a few erect fascicles of hyphae, arising from the stroma, surrounding the base of the stalk.

The hyphae of the sheath are united here and there by ladder-connections, i.e. short junctions perpendicular to the hyphae (Plate V, fig. 16). These ladder connections are, however, much more common, and more easily found, between the unbranched bases of the conidiophores. They were noted by the Tulasnes.

The head, normally, is ovoid, but frequently it is curved into a hook, or produced into a point often perpendicular to the stalk. The latter form is, in a sense, accidental. The conidia do not fall off, or blow away, but remain united in a mass by some soluble substance. The fungus grows on scale insects attached to branches, as a rule, and consequently is most generally perpendicular to the branch. But as the branch is often erect or oblique, the mass of conidia bends downwards by its own weight, and thus may become perpendicular to the stalk. The occurrence of dozens of synnemata on the same branch, all with their heads curved in the same direction appears most remarkable until the reason is perceived.

The conidia of *Microcera* (Plate V, fig. 10) are typically narrow-cylindric, or fusoid, nearly straight with falcate tips, 60–120 μ long, 5–8 μ diameter, up to eleven septate, the ends subacute, the distal end being rather more obtuse than the proximal. Sometimes they are quite straight, and sometimes slightly and uniformly curved.

The species of *Microcera* on scale insects are orange red and subtranslucent when fresh, and become brownish red, hard, and horny when dry. When placed in water, the head expands and the outer conidia float off. The synnemata generally arise from a very narrow stroma round the scale; this stroma is tomentose, and, if of any considerable thickness, is composed of interwoven hyphae.

In addition to the stilboid form, reduced forms occur in all the known species of *Microcera*. These may be clavate, with a barely recognisable stalk, or quite sessile, flattened pulvinate, circular or oval in plan, usually seated on the narrow stroma at the margin of the scale (Plate III, fig. 2). These sessile forms may occur together with the stilboid form, or a gathering may consist entirely of either kind. The sessile fructifications are composed of closely packed conidiophores, which arise almost directly from the basal stroma; they are surrounded by a sheath similar to that of the stalked forms.

In the forms from temperate countries, the sessile form of

fructification usually predominates, and the stilboid form, if present, is generally small. Desmazières stated that the clava was scarcely 0·5 mm. high. In the specimen, Desmazières, Plantes Cryptogames de France, Ed. II, Ser. I, No. 1350, in Herb. British Museum, the synnemata are clavate, or conical, or flattened pulvinate; the clavate and conical examples are up to 0·6 mm. high, and 0·3 mm. diameter; the flattened pulvinate examples are up to 0·6 mm. diameter. In *Sphaerostilbe flammea*, Ellis, North American Fungi, No. 1333 (issued as *Nectria subcoccinea* Sacc. and Ellis), the synnemata are conical, 0·35 mm. high, 0·25 mm. diameter at the base, or flattened pulvinate, up to 0·5 mm. long, 0·25 mm. broad.

The sheath in the temperate forms differs from that in the tropical examples in that the teeth tend to divide above into separate hyphae. In some instances, however, the sheath forms a thin membrane which persists after the dispersal of the conidia. An example in Erbar. Crittogam. Ital., Ser. II, No. 542, from which all the conidia had disappeared, consisted of a short stalk 0·1 mm. diameter, surmounted by a membranous cup about 0·1 mm. high, no hyphal structure being discernible in the membranous edge.

Another point of difference lies in the relative development of the conidia and the conidiophores. In the tropical forms, conidia are produced abundantly and there do not appear to be any barren conidiophores or paraphyses: the outer part of the head is a mass of conidia. In the temperate forms, on the other hand, conidia are sparingly produced, and very many of the conidiophores appear to be barren. Desmazières noted that the conidia occurred among the filaments and were few in number, and in some pulvinate examples in his specimens, the barren (?) filaments are so numerous towards the exterior, that the fructification has a distinct white margin. The conidia too are less perfectly developed in the temperate examples. *Nectria aurantiicola* in the tropics has conidia with well-defined septa, while in *Microcera coccophila*, the septa tend to be obscure. But the conidia of *Nectria aurantiicola* from Italy, have obscure and irregularly arranged septa.

No criteria have been found by which it would be possible to distinguish with certainty between the *Microcera* stages of the different species of *Sphaerostilbe* parasitic on scale insects. It is necessary to have examples which have developed the perithecial stage.

Of the species which have been described as *Microcera*, *Microcera Parlatoriae* Trabut, *Microcera curta* Sacc., and *Microcera Tonduzii* Pat. are *Fusarium*, *Microcera Fujikuroi* Miyabe and Sawada and *Microcera Merrillii* Syd. are *Pseudomicrocera*.

Microcera tasmaniensis McAlp. and *Microcera Mytilaspis* McAlp. differ generically from *Microcera* and the foregoing species. *Microcera rectispora* Cke. and Massee is *Tetracrium*. *Microcera pluriseptata* Cke. and Massee, which was said to grow on *Calocera*, is on a scale insect, the supposed *Calocera* being the effete *Microcera* synnemata; this species is *Microcera coccophila* Desm.

PSEUDOMICROCERA.

The second type of conidial fructification which is common on scale insects in the tropics occurs on *Lepidosaphes* (*Mytilaspis*), *Aspidiotus*, *Fiorinia*, *Aonidia*, etc. It was named *Microcera Fujikuroi* by Miyabe and Sawada on specimens from Formosa in 1913, and *Microcera Merrillii* by Sydow on specimens from the Philippines in 1914. In Florida, it has generally been assigned to *Microcera coccophila* Desm., and the majority of the specimens distributed from Florida to European herbaria under that name are *Pseudomicrocera*. It is figured as *Microcera coccophila* by Fawcett in Fungi parasitic on *Aleyrodes citri*, fig. 14, and by Parkin as *Microcera* (figs. 62–66). As it is a common fungus, it may be expected to have been named in the earlier days of mycology without reference to its real host, but it has not been found among the species of *Fusarium* in Herb. Kew or Herb. British Museum. The earliest name yet found for it is *Aschersonia Henningsii* Koorders (type specimen in Herb. Berlin examined), described from specimens from Java in 1907.

The mature perithecial stage of this species has been collected in Brazil, Paraguay, Cuba and Ceylon, and immature perithecia have been found in a specimen from Mauritius. These are *Nectria diploa* B. and C.; the type specimen of the latter contains effete *Pseudomicrocera* sporodochia.

It has not been found possible to differentiate between the specimens of *Pseudomicrocera* from different countries, with the exception that specimens from West Africa have much longer spores than the others. For the present, they must all stand as *Pseudomicrocera Henningsii* (Koord.), while the West African form may be known as var. *longispora*. It is probable, however, that when further specimens of the *Nectria* stage have been collected, *Pseudomicrocera Henningsii* will be found to be a collective species.

The fungus (Plate III, figs. 9–12) forms a thin, but compact, stroma, sometimes glabrous and shining, either at one side of the scale, or as a narrow margin all round it. In some cases, e.g. on *Aonidia* (Plate III, fig. 9), the stroma also grows centripetally over the scale. From this stroma there arise conidial fructifications in varying numbers. In a few instances, no stroma

is visible, and the fructifications appear to arise from the margin of the scale. In general, the fructifications lie flat on the host plant, radiating from the scale, but they are frequently directed obliquely upwards. They are seldom, or never, quite erect.

Each conidial fructification (Plate III, fig. 11) consists of an ovoid, subcylindric, or cushion-shaped base, contracted above and below, as a rule, and surmounted by a conical tip. The distinction between the basal portion and the conical tip is usually well-marked, as the two parts differ both in colour and structure. But in some cases the base is reduced to a height of about 0·2 mm. or less, and then only the conical tip is immediately evident (Plate III, fig. 12).

In well-developed examples, the basal part is ovoid, red, minutely rough, pruinose, and opaque, and has the appearance of a red *Nectria*. In general, however, the base is broader than it is long or thick, and may have a breadth of 0·6 mm., with a height of 0·2 mm. Its sides are usually curved, so that it is constricted above and below, but in the form on *Aonidia* (Plate III, figs. 9, 10) there may not be any constriction above, and the fructification then tapers gradually from the point of attachment to the apex. In small examples, the base is often translucent.

The conical tip consists of long, parallel hyphae, united into narrow triangular teeth, or sometimes into a sheet which is almost continuous. These teeth converge at the apex, in general, but they may stand more or less parallel to one another. As a rule, the tip greatly exceeds the base in length. It may be pinkish when fresh, but on old examples, or in herbarium specimens, it is white.

In the majority of specimens the base is composed of interwoven hyphae. These hyphae are irregular, rather closely septate, constricted at the septa, and with strongly inflated segments, or moniliform, consisting of a chain of more or less rounded cells. These cells are usually filled with a red plasma. The stroma from which the fructification arises has the same structure. The hyphae in this case separate under pressure. They have been figured by Miyabe and Sawada for *Microcera Fujikuroi*.

In the larger examples the development of the base has advanced further, and the hyphae are fused together so that the base is parenchymatous. This happens in the common Ceylon form on *Lepidosaphes*, etc., but it is most frequent and most clearly evident in specimens from Florida and the West Indies. In section the base consists of polygonal thick-walled cells, without coloured contents, hyaline in the centre, but reddish, or red-brown, towards the exterior.

Further details of the structure of this conidial fructification are most easily ascertained from these larger examples. Longitudinal sections show the following.

Towards the top of the parenchymatous base, the cells, though still irregular, become more elongated in a longitudinal direction. This is more especially marked in the central portions. From these elongated cells, there arise short conidiophores which form a continuous disc over the upper surface of the parenchymatous base. The marginal cells of the base, however, give rise to long, septate hyphae which are united into fascicles. These fascicles converge above and constitute the conical apex. Viewed from the exterior they are long-triangular: in section they are several hyphae thick at the base, and in some cases there is, at the base of the fascicle, a distinct inner and outer layer of parallel hyphae separated by a layer of parenchymatous tissue which gradually becomes thinner and disappears at a short distance from the base. On the inner side of these fascicles there may be a small number of long, septate hyphae, similar to those which form the fascicles, but free, and constituting "paraphyses."

The structure consequently resembles that of a Discomycete. The parenchymatous base is to some extent differentiated into a "hypothecium" of elongated cells which bear the conidiophores, and an "epithecium" of more isodiametric cells. The long marginal hyphae arise from the uppermost cells of the "epithecium."

This structure is illustrated diagrammatically on Plate V, figs. 20 and 21. Fig. 20 shows the base and the tip viewed from the lower surface, the wall of the tip being shown as continuous. Fig. 21 is a longitudinal section of a well-developed specimen with a parenchymatous base and the teeth on the upper side longer than those on the lower.

The conical tip was designated by Parkin a "loose sheath" in contradistinction to the "closely adherent sheath" of *Microcera* (*Fusarium* of Parkin). But, although it resembles the latter in being composed of long, septate hyphae, which are united by ladder connections, it differs from it in several particulars. It is not a continuation of the outer layer of the base, but differs entirely in structure from the latter. It is composed, at least in the lower part, of several layers of adherent hyphae. It does not sheath the bases of the conidiophores but is a marginal border to a slightly concave disc, and encloses a mass of detached conidia.

In many cases, the hyphae which constitute the segments of the tip are not of the same length all round the disc. It has already been stated that the fructification is rarely erect, but usually horizontal and often oblique. The hyphae of the teeth

on the lower side are often shorter than those on the upper. Consequently, when the fructification is viewed from below, large specimens show an oval opening, through which the orange-coloured disc may be visible. The sporodochium then resembles a small *Otidea*.

The marginal hyphae may be united into a continuous layer surrounding the disc, or divided into teeth or segments to varying depths from the apex. In some forms, this envelope is continuous up to the apex on the upper side, and divided down to the base in the median line on the lower.

The conidiophores are short, as a rule. They are at first unbranched and about 30 μ long, but become branched and about 60 μ long. They resemble the conidiophores of *Microcera* in diameter and branching, but are very considerably shorter. It is possible that they may attain a greater length in some species, but in all the cases observed, the ultimate branches are short, and the conidiophore branched almost from the base. Probably because of the shortness of the conidiophores, ladder connections between them are absent, or at least rare.

The conidia are long, three to five septate with long aseptate tips, and, in the forms examined, are usually regularly curved from tip to tip (Plate V, fig. 17). They remain for some time enclosed within the tip in an orange, or coral-red, mass, the apex of which projects slightly, but, judging from the available specimens, they are more readily dispersed than those of the true *Microcera*.

The structure of this conidial form is evidently quite different from that of the *Microcera* described by Desmazières; and it does not appear to agree with any existing genus. I therefore propose for it a new genus, *Pseudomicrocera*.

Pseudomicrocera. Sporodochium conical; base ovoid, or cylindric, or pulvinate, parenchymatous, or composed of interwoven irregular hyphae, surmounted by a discoid layer of conidiophores with a marginal zone of long hyphae, united into a continuous sheet or into fascicles of varying breadth, which are connivent at the apex; conidiophores branched; conidia elongated, narrow, curved, septate, hyaline.

The following forms of *Pseudomicrocera* have been examined.

A. Specimens on *Aspidiotus* on *Citrus*, Florida, U.S.A. (Plate III, fig. 11), and on *Aspidiotus* and *Ischnaspis filiformis*, on Coffee, Grenada, West Indies.

The sporodochia are oblique or horizontal. The scale at first has a radiating byssoid margin, which develops into a more compact yellowish-white stroma, at the side of, or covering, the scale. The sporodochia may arise from the margin of the scale, or from the stroma. In some cases the sporodochium arises at

the side of the scale from a more or less circular, thin, parenchymatous disc, which separates from the leaf with the sporodochium. The stroma may be floccose or parenchymatous.

The total height of the sporodochium is, as a rule, up to 0·8 mm., but specimens up to 1·5 mm. high occur. The base is subcylindric, but usually broader than high, and somewhat compressed from front to back. Large specimens have a base 0·6 mm. broad, and 0·5 mm. high; in smaller examples, it is about 0·5 mm. broad and 0·3 mm. high. The base is pinkish-red, opaque, with a delicate white pruina, and is usually contracted above and below. The tip is conical, longer than the base, white or pinkish, divided into segments or teeth to varying depths. The teeth are shorter on the lower side of the sporodochium, and, hence, when it is viewed from the lower side, the orange-red disc is visible through an elongated oval opening, more especially in the larger specimens.

In section, the base of the larger specimens is parenchymatous, being composed of polygonal, rather thick-walled cells, 4–6 μ diameter, with a few 10 μ diameter. The exterior cells are smaller than those in the interior and have reddish walls. The hyphae of the tip are 4 μ diameter, equal, septate, united by ladder connections. In large specimens, the teeth are up to 120 μ thick at the base on the upper side, and 60 μ thick in the corresponding position on the lower. The conidiophores are simple, or closely branched, 3 μ diameter, equal, up to 50 μ long in the centre of the disc, longer towards the margin.

The conidia are arcuate, sometimes almost straight with curved tips, generally three-septate, but sometimes four- or five-septate, hyaline; in the Florida specimen they measure 60–70 × 3–5 μ; in the Grenada specimen, 50–66 × 3 μ, measurements made straight from tip to tip. In the latter specimen, the conidia tend to collapse laterally.

This form differs from the common Ceylon form in that the base is more usually parenchymatous, and the conidia, on the average, are shorter.

B. On *Lepidosaphes*, *Aspidiotus*, *Fiorinia*, *Ischnaspis*, from Ceylon, India, Australia, Mauritius, Java, and Formosa (Plate IV, fig. 12).

The stroma is narrow, compact, slightly irregularly pulvinate, tomentose, with a radiating byssoid margin. The marginal hyphae tend to fuse into a membranous hyaline sheet. The stroma may completely surround the scale or be confined to one side. As a rule it does not grow over the scale, but it may completely cover small examples. In some cases, the sporodochia appear to arise direct from the scale, no stroma being visible externally. The sporodochia are horizontal, as a rule.

The base of the sporodochium is pulvinate, pinkish-red, opaque or subtranslucent, tomentose, 0·2 to 0·6 mm. broad, and 0·06 to 0·2 mm. high. The total height of the sporodochium is up to 0·6 mm. The marginal teeth are long, triangular, divided down to the base, usually connivent, either of equal length all round, or shorter on the lower side.

In herbarium specimens the stroma and base of the sporodochium become yellow.

The conidia are arcuate, equally curved, hyaline, three- to five-septate. Measurements from different gatherings have given, 80–100 × 4 μ; 80–90 × 4–4·5 μ; 82–92 × 3–5 μ (Mauritius); 76–94 × 4 μ; 74–92 × 3–4 μ.

I have examined the following collections of this form. On *Fiorinia rubrolineata* on *Murraya exotica*, Ceylon. On *Ischnaspis* sp. on *Funtumia*, Ceylon. On *Lepidosaphes* sp. on orange, Ceylon. On *Mytilaspis pallida* on *Codiaeum variegatum*, Ceylon (Parkin's specimen). On *Aspidiotus* sp. on *Hevea*, Ceylon. On *Fiorinia fioriniae* on *Camellia*, Mauritius (Parkin's specimen). On a diaspid on Tea, Java. On *Aspidiotus* on orange, Jorhat Farm, Assam (E. J. Butler). On scale on *Indigofera*, Bassein, Burma (E. J. Butler). On *Aspidiotus ficus* on *Citrus*, Port Darwin, N.T., Australia.

Specimens of *Microcera Fujikuroi* Miyabe and Sawada from Herb. Sapporo have been kindly lent me by Prof. Ito. One, on *Aspidiotus ficus* Comst. on *Citrus nobilis*, Sensoho, Formosa, October 30, 1906, has stromata either hidden by the scale, or forming a narrow border on one side, or covering the scale except in the centre. The sporodochia are horizontal, spreading stellately from the scale. The base is small, about 0·1 mm. high. The conidia are curved, equally attenuated, usually five-, sometimes six-septate, with long aseptate tips, 72–94 × 3–4 μ; they tend to collapse laterally, like those of the West African form noted below. The hyphae of the teeth are slightly stouter, and have thicker walls, than in specimens from other countries, but in other respects they do not differ from the Ceylon form on *Aspidiotus*.

The type specimen of *Microcera Fujikuroi*, on *Aspidiotus ficus* Comst. on *Citrus nobilis*, Taihoku, Formosa, February 29, 1908, is identical with the foregoing, but poorly developed. From Prof. K. Hara, I have received specimens on *Abies firma*, Shizuka, October, 1918.

A specimen, *ex* Herb. Victoria, on *Aspidiotus ficus* on *Citrus*, Port Darwin, N.T., July 13, 1915, has a narrow, pink, fimbriate stroma round the scale, with the sporodochia lying horizontally on the leaf or emerging from the apex of the scale. The sporodochia are variable, some having an opaque base, 0·1 mm. high,

with a white tip 0·3 mm. high, while others appear wholly translucent, the tip being filled with an orange-yellow mass of conidia. The conidia are of the usual form, or almost straight with curved tips, up to five-septate, 70–90 × 4 μ.

In another Australian gathering, on *Lepidosaphes* sp. on *Melaleuca leucadendron*, Stapleton, N.T., the stroma is dark red, subtranslucent, irregular, either situated at one side of the scale or overgrowing it completely. It is somewhat adhesive, and though the specimen was collected about fifteen years ago, it still adheres to paper if lightly pressed. The sporodochia have broad bases, up to 0·4 mm. broad, and 0·3 mm. high, but in some the base is almost absent. The bases have the same colour and appearance as the stroma, and are slightly longitudinally tomentose. The tip is short, white, conical, up to 0·15 mm. high, sometimes represented by a few scattered teeth only, in the available specimens. The conidia are arcuate, equally curved, tapering regularly to the tips, a few nearly straight, generally five-septate, 72–94 × 4 μ. This differs from the common Ceylon form in its shorter tip and subtranslucent waxy stroma.

Microcera Merrillii Syd. (Ann. Myc. XII, p. 576), on a scale on *Eugenia perpallida* from the Philippines, would appear to resemble the foregoing. I have examined the co-type, S. 259, Herb. Bureau Sci. Philippines, which contains very few stromata, and those all immature. The stromata are dark red, subtranslucent, waxy, covering the scale or spreading from it on one side rather more widely than in the usual form. The largest stroma found was flattened convex, about 0·8 mm. diameter. The structure of the stroma is not that of the true *Microcera* but that of *Microcera Fujikuroi*. Sydow describes the sporodochia as pale blood red, sessile, generally confluent in small masses 1–1·5 mm. diameter, and the conidia narrow fusiform, straight or subfalcate, three-septate, with acute tips, 40–60 × 3·5–4 μ. I was unable to find conidia in the co-type, but those described by Sydow evidently agree with those of *Microcera Fujikuroi*, not with those of *Microcera coccophila*. Sydow compared his species to *Microcera tasmanica* McAlp., but it has not the structure of the latter.

Both *Microcera Merrillii* and the Australian specimen on *Melaleuca* yield a white precipitate when treated with alcohol. That characteristic, however, is not confined to these subtranslucent forms, but has been noted in an opaque form from Grenada.

Hennings in 1903 (Engler's Bot. Jahrb. p. 57) described *Fusarium coccidicola* on a coccus on leaves of Tea, Ost-Usambara, East Africa. The sporodochia were said to be effused, waxy, cinnabar, with fasciculate, simple, septate, rosy-hyaline hyphae,

100–250 × 4 μ. The conidia were elongato-fusoid, falcate, multiguttulate or obsoletely septate, with subacute tips, pinkish hyaline, 80–100 × 3·5–4 μ. I have not seen the type specimen, but from the description of the stroma and the conidia, this would appear to be *Pseudomicrocera*.

C. Specimens on *Aspidiotus articulatus* on Coffee, Soto, West Africa. This collection was enumerated by Parkin. In general appearance, it resembles the Ceylon specimen on *Aspidiotus* on *Hevea*. In some cases the scale is surrounded by a narrow stroma, with a fibrillose margin which may spread out over the leaf for a distance of two or three millimetres; in others, no stroma is visible, and the bases of the sporodochia are partly hidden by the scale. The sporodochia lie flat on the leaf, radiating in star fashion from the scale. Their bases are small, not exceeding 0·2 mm. in height, but the white tip is well developed. The teeth are distinct down to the base; viewed from the lower surface, they may be widely separated or not. The conidia are of the usual type, arcuate, equally curved, with tapering points, three- to five-septate, readily collapsing, 92–134 × 3 μ.

This form differs from the common Ceylon species, only in the greater length of its conidia. It may be known as var. *longispora*.

D. Specimens on *Aonidia*, Ceylon. Specimens on *Aonidia crenulata* on *Memecylon* (Plate III, figs. 9, 10), and *Aonidia bullata* on *Nothopegia Colebrookiana* were described by Parkin. The former is common on a group of *Memecylon edule* in the Royal Botanic Gardens, Peradeniya; of the latter, I have only the specimens referred to by Parkin.

On *Aonidia crenulata*, the fungus forms a narrow stroma, up to 0·25 mm. wide, either all round, or at one side of, the scale. This stroma is pinkish-red, thin, compact, with a whitish, fimbriate margin, and often radially grooved. It usually grows centripetally over the scale, as well as centrifugally over the leaf, but the centre of the scale is generally left exposed. The scale appears red, or scarlet, owing to the growth of the fungus beneath it, and the naked centre is more vividly coloured than the stroma. In wet weather, the stroma is coral red; when dry, it has a delicate covering of scattered, whitish hyphae.

The sporodochium almost always arises at the inner edge of the stroma, so that it is perched on the top of the scale, as a rule. Also, it usually arises from the extreme edge, and is attached to the stroma, not over its whole base, but at one side, so that at first sight it appears to be disconnected from the stroma. Generally only one sporodochium is borne on each scale, but there may be two. It is usually oblique, rarely horizontal.

The total height of the sporodochium is up to 0·9 mm. The base is ovoid or cylindric, 0·4 mm. high and 0·3 mm. diameter, with a conical tip, 0·5 mm. long. When moist, the whole fungus is subtranslucent, pinkish-red or coral-red, but when dry it appears whitish or pinkish, and minutely pruinose.

The wall of the conical tip may be divided into teeth, as in the common form, but it is frequently continuous, except for a fissure extending along the whole length of the tip in the median line on the lower surface. Sometimes this fissure is narrow, rather broader above than below: in other cases, its sides are curved as shown in diagram 20, Plate V. The hyphae which form the wall of the tip are 4 μ in diameter, equal, septate, and united by ladder connections. The wall is rather thick and fimbriate at the apex, and numerous long free hyphae, parallel, and similar to those which compose the wall occur on the inner side.

In dry-weather forms, the sporodochium is uniformly conical without any evident constriction between the base and the tip. At other times, the sporodochium is constricted, and often curved.

The conidiophores are short, 30–66 μ, simple or branched. The conidia are arcuate, tapering uniformly to the ends, usually three-septate, a few five-septate. The septa are obscure, and apparently tardily developed. It is not uncommon to find the majority of the spores without septa. The aseptate tips are usually long, up to 20 μ. Measurements of different collections have given the following dimensions: 70–86 × 4 μ; 84–96 × 3·5–4 μ; 66–82 × 3·5–4 μ; 38–64 × 3–4 μ, some only 16–30 μ (dry weather); 70–80 × 3·5–4 μ.

When the tip is filled with spores, the mass projects at the apex as a coral-red point.

The specimen on *Aonidia bullata* mentioned by Parkin is similar to the above, but the sporodochia arise in the middle of the stroma, not at its edge. The spores are arcuate, three-septate, 70–80 × 4 μ.

A curious abnormality of the form on *Aonidia crenulata* has been collected. It occurred on *Memecylon* with the normal form, the latter usually on the under surface of the leaf, and the abnormal form on the upper. No scale insects were visible on the upper side of the leaf, but it was covered with small, curved, hyaline, claw-like thorns, standing up obliquely. Each of these thorns arises from a broad, circular, hyaline, membranous, scarious patch up to 0·8 mm. diameter, which can readily be detached from the leaf. The thorn-like projection is about 0·6 mm. high, strongly laterally compressed, and about 0·25 mm. broad. The convex edge is regular, but the lower edge, viewed

from the side, appears to be interrupted by a deep narrow sinus (Plate V, fig. 8 *b*). Viewed from the convex edge, two auricles are seen, projecting one on either side at the base (fig. 8 *a*), while, from the concave side, it is seen that the two sides of the structure fold together and nearly meet above, but separate again widely near the base (fig. 8 *c*).

The wall of this structure is thin, continuous, and hyaline, and is composed of parallel hyphae, about 3 μ diameter, united side by side in a continuous sheet, and joined laterally by ladder connections. Within it, at the base, there is a very minute parenchymatous mass of hyaline cells, from which a few unbranched conidiophores arise, but no conidia have been found.

A comparison of figs. 8 and 20, Plate V, will make it clear that these thorns are the walls of the conical tips of the *Pseudomicrocera*, and their structure supports that interpretation. But they are not *Pseudomicrocera* sporodochia from which the conidia have disappeared, as the base is practically entirely lacking. For some reason, only the wall of the tip has been developed, and that has taken the form of a hyaline membrane. They appear to have grown on very small specimens of *Aonidia*.

It may be noted that the tendency to produce scarious membranes is well-marked in most of the fungi which grow on scale insects. It occurs, for example, in *Aschersonia* and *Hypocrella*, where the stroma is often surrounded by a scarious hypothallus; and one may meet with the same hypothallus, indiscriminately, in gatherings of *Sphaerostilbe* and *Microcera*.

SPHAEROSTILBE.

Sphaerostilbe coccophila Tul.

This species was first described by the Tulasnes in Selecta Carp. Fung. I, p. 130 (1861), where they cited the specimens *Microcera coccophila* Desm., Desmazières, Plantes Cryptogames de France, Ed. II, Ser. I, No. 1350 as the conidial stage, and Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda, Nos. 262 and 269 as the perithecial stage. Rabenhorst 262 had been issued as *Nectria episphaeria* Tode, and 269 as *Microcera coccophila* Desm.

The description was repeated in Selecta Carp. Fung. III, p. 105, where Rabenhorst 262 only is cited for the perithecial stage, but Desmazières, Plantes Cryptogames de France, Ed. I, Ser. I, No. 1750 is added to the former citation for the conidial stage.

Desmazières 1350 and 1750 were collected near Caen (Normandy) and Rabenhorst 262 and 269 at Florence, Italy.

According to the Tulasnes' description, their species forms a

narrow byssoid stroma, pallid or pale rose, round the scale. The synnema is about a line high, with a deep red head consisting of linear lanceolate, curved conidia, three- to five-septate, 65 × 6 μ. The perithecia arise at the base of the synnema, or on stromata which lack synnemata; they are minute, globose, obtusely and very shortly papillate, very smooth, shining red, fleshy and fragile, collapsing when dry, clustered in groups of three to five. The asci are cylindric, 60–80 × 6·5 μ, obtuse, subsessile, eight-spored. The ascospores are ovate, subhyaline, one-septate, somewhat constricted at the septa, ends obtuse, 10 × 5 μ.

Seaver (Mycologia, 1, p. 180) regards *Sphaerostilbe coccophila* Tul. as identical with *Nectria subcoccinea* Sacc. and Ellis, and suggests that it is also identical with *Nectria aurantiicola* B. and Br. and *Nectria aglaothele* B. and C. He states that the synnema consists of a short stout stalk with an orange head, the conidia being straight, or more often curved, fusiform, three- to seven-septate, 50–90 × 5–6 μ, occasionally shorter; and that the perithecia are more or less caespitose, bright orange, with a prominent, rather acute ostiolum, and contain cylindrical asci, 75 × 8–10 μ, with elliptical or subelliptical spores, 12–18 × 7–9 μ. He cites the American specimens, Ellis, North American Fungi, No. 1333 (issued as *Nectria subcoccinea*); Ravenel, Fung. Car. Exsicc., No. 57 (issued as *Nectria muscivora* Berk.); and Hume, Florida, No. 39. The dimensions given for the ascospore give occasion for doubting the identity of the fungus described by Seaver with that described by the Tulasnes.

Von Höhnel and Weese state that *Nectria subcoccinea* Sacc. and Ellis (1882) is identical with *Nectria Colletiae* Rehm (1898) and *Nectria coccidophthora* Zimm. (1901) *from the descriptions*; and again that *Nectria Colletiae* Rehm is identical with *Nectria subcoccinea* Sacc. and Ellis, and, *fide* Seaver, with *Sphaerostilbe coccophila* Tul.

In order to clear up the synonymy suggested by the authors cited, an examination has been made of as many as possible of the type specimens, or of authentic specimens, of the species referred to. *Nectria Colletiae* Rehm is the only species not available in Herb. Kew, Herb. British Museum, or Herb. Peradeniya. The conclusions arrived at are stated here briefly; reference to the specimens examined will be made when dealing with the species individually.

To differentiate accurately between the different species of *Microcera* it is necessary to have the perithecial stages. In the conidial stage, they are all very similar, and though it appears possible to distinguish the conidia of *Microcera coccophila* from those of *Microcera aurantiicola* when both have been collected

in the tropics, the distinction fails when the specimens have originated in temperate countries.

The Tulasnes noted that in their perithecial specimens from Florence, Rabenhorst 262 and 269, the conidial stage was rare. In the specimens in Herb. British Museum and Herb. Kew, Rabenhorst 262 is apparently entirely perithecial, while Rabenhorst 269 contains the conidial stage, as well as immature perithecia. The latter is a poor development, the scales being scattered, not crowded as in other specimens from Florence. Although Rabenhorst stated, in the description which accompanied the specimen, 262, "ascos non vidi," it contains mature perithecia, and from these it is evident that the species is identical with that described from Ceylon by Berkeley and Broome as *Nectria aurantiicola*.

The conidial stage in Desmazières 1350 will be described later. But the specimens also contain perithecia, and these are identical with *Sphaerostilbe flammea* Tul.

Sphaerostilbe flammea differs from *Nectria aurantiicola* both in its perithecia and its ascospores. Consequently, *Sphaerostilbe coccophila* Tul., according to the specimens cited by the Tulasnes, consists of the perithecial stage of one species and the conidial stage of another. The Tulasnes named their species on the assumption that Desmazières' fungus was the same as that from Florence. But *Microcera coccophila* Desm. is the conidial stage of *Sphaerostilbe flammea*, not of *Sphaerostilbe* (*Nectria*) *aurantiicola*.

The synonymy quoted above (p. 110) is correct in that *Nectria aglaothele* and *Nectria subcoccinea* are identical with the species issued by Ravenel as *Nectria muscivora*; but they are not identical with the perithecial stage of *Sphaerostilbe coccophila*, though their conidial stage is *Microcera coccophila*. Nor are they identical with *Nectria aurantiicola* or *Nectria coccidophthora*.

It might be suggested that, as the perithecial stage of *Sphaerostilbe coccophila* is identical with *Nectria aurantiicola*, the latter name should be discarded. It would, however, still be necessary to retain *Microcera coccophila* for the conidial stage of *Sphaerostilbe flammea*, and the use of the same specific name for the two different stages of two different, though closely allied, species would undoubtedly lead to confusion. Moreover, it is quite certain that the Tulasnes' name was chosen on erroneous grounds.

One is loth to propose the abolition of a name which has been so widely employed in the literature of economic mycology. On the other hand, this reluctance is tempered by the knowledge that the name has usually been wrongly applied. *Sphaerostilbe coccophila* Tul., as it stands at present, is a compound species,

and it would certainly appear preferable to employ the names of species which have been more accurately defined, viz. *Sphaerostilbe flammea* Tul., *Sphaerostilbe aurantiicola* (B. and Br.), and *Sphaerostilbe coccidophthora* (Zimm.).

The three species of *Sphaerostilbe* parasitic upon scale insects, though undoubtedly closely allied, may be distinguished by the following characters.

Sphaerostilbe flammea Tul. Perithecia usually caespitose on a well-developed stroma, bright orange red, glabrous, globose, collapsing centrally; ostiolum minute, conical or inconspicuous; ascospores 12–19 × 5–8 μ.

Sphaerostilbe aurantiicola (B. and Br.). Perithecia usually scattered without evident stroma, dark red, subtranslucent, conoid, glabrous or with a few yellow granules, collapsing laterally; ostiolum papillate; ascospores 9–14 × 4–6 μ.

Sphaerostilbe coccidophthora (Zimm.). Perithecia usually scattered on a slight stroma, dark red, covered with yellow granules, conoid or subglobose, subtranslucent, collapsing laterally; ostiolum papillate; ascospores 13–22 × 7–9 μ.

In *Microcera coccophila*, the conidia are more often fusoid and straight from tip to tip than in *Microcera aurantiicola*; the typical conidium of the latter, and of *Microcera coccidophthora*, is almost straight with falcate tips. In *Microcera aurantiicola*, the septa of the conidia are usually more strongly defined than in *Microcera coccophila* or *Microcera coccidophthora*.

Berkeley and Broome described the perithecia of *Nectria aurantiicola* as "in stromata erecto sitis," and they gave a figure illustrative of that. Their description and figure are supported by a specimen *ex* Herb. Broome in Herb. British Museum, which shows that the erect stroma is a *Microcera* synnema. Parkin, in his figure No. 9, showed the perithecia situated in two instances on the stalk of the synnema. That, however, is not the usual mode of occurrence of the perithecia in *Nectria aurantiicola* and it is exceptional, even in Broome's specimen. In the most general case, the perithecia occur on scale insects which do not bear the conidial stage. When they occur in company with the conidial stage, they do sometimes occur on the stalks of the old synnemata, and developing perithecia may also be found in the head among the conidia. But out of about twenty Ceylon gatherings, I have only one in which they occur in those positions No. 542, Erbar. Crittogam. Ital., Ser. II, issued as *Sphaerostilbe coccophila*, also bears developing perithecia on the synnemata.

The Tulasnes figured *Sphaerostilbe flammea* with developing perithecia on the synnema. The type specimen of *Nectria laeticolor* B. and C. which is *Sphaerostilbe flammea* has perithecia

in that position in some instances, and the same is true of the type specimen of *Microcera pluriseptata* Cke. and Massee, which is identical with *Microcera coccophila* Desm., the conidial stage of *Sphaerostilbe flammea*. This has not yet been observed in *Sphaerostilbe coccidophthora*, but the available collections of the latter species are few in number.

Relying upon Berkeley and Broome's description and figures, von Höhnel has transferred *Nectria aurantiicola* to *Corallomyces* because it has perithecia on the synnemata. Obviously, in that case, *Sphaerostilbe flammea* must be transferred to *Corallomyces*, and this has been effected by von Höhnel in Herb. Kew, as far as regards the type of *Nectria lacticolor*. On this classification, the closely-allied *Nectria coccidophthora* must be left in *Sphaerostilbe*. But the production of perithecia on the synnemata is exceptional in both *Sphaerostilbe aurantiicola* and *Sphaerostilbe flammea*, and it does not seem reasonable to separate those two generically from *Sphaerostilbe coccidophthora* on a character which is seldom developed.

The genus *Corallomyces* was established by Berkeley and Curtis in 1853, the type species being *Corallomyces elegans*, described from specimens from Surinam in the Schweinitz Herbarium. It was said to have a branched stroma, with filiform and palmate branches, and to be a Hypocreaceous genus corresponding to *Xylaria*. Berkeley and Curtis published figures of their species (Journ. Acad. Sci. Philadelphia, n.s. II, Table XXV, fig. 2), showing short, simple, or slightly branched, clavae, in one case flattened at the tip. Another figure, by Lindau, was published in Engler-Prantl., Pflanzenfamilien, Th. I, Abt. I, p. 366; it shows a shrubby growth of suberect, much branched stems, arising from the same point. The latter figure is said to be original, but there is no indication of the origin of the specimen from which it was taken. The type specimen of *Corallomyces elegans* in Herb. Kew, "*Corallomyces elegans* B. and C., *Sphaeria pseudovillosa* Schw., Surinam, Herb. Schwein." is a dense group of old synnemata, arising side by side from the substratum; some of these are once branched, others simple, and there appear to be a few horizontal rhizomorphs in addition; the perithecia are borne on the old synnemata. There is nothing in the type specimen which would support Lindau's figure.

Corallomyces is merely a *Sphaerostilbe* which has produced perithecia on the old synnemata. The type species, *Corallomyces elegans*, is closely allied to *Sphaerostilbe repens*, a rhizomorphic species which may produce perithecia on the rhizomorphs or on the old synnemata. It would appear to be the rule rather than the exception, that species of *Sphaerostilbe* may produce

perithecia on the old synnemata. The distinguishing character of *Corallomyces* is the possession of a branched, filiform stroma, resembling that of a *Xylaria*, but that is based on a mistaken interpretation of the type specimen. Von Höhnel places in *Corallomyces* those species of *Nectria* which have the perithecia situated on a stalk-like stroma; in dealing with *Nectria aurantiicola*, he states (Fragm., No. 729) "Da die Perithecien auf einem stielartigen Stroma entstehen ist der Pilz eigentlich ein *Corallomyces*." But he does not appear to recognise that the stalk-like stroma is an old synnema, nor that the occurrence of the perithecia in that position is exceptional.

The Tulasnes employed the name *Sphaerostilbe* in Selecta Carp. Fung. I, 130 (1861), though they did not publish the generic description until 1865, in vol. III, p. 99. They included in the genus (in the following order), species with minute simple conidia and a *Stilbum* conidiophore, viz. *Sph. aurantiaca*, *Sph. gracilipes*, and *Sph. cinnabarina*, and species with long lanceolate, septate conidia and a *Microcera* conidiophore, viz. *Sph. flammea* and *Sph. coccophila*. Their genus is evidently heterogeneous, as it contains species which differ in their conidial stages, and it can be naturally divided into two genera, one with simple conidia and the other with lanceolate, septate conidia.

Corallomyces is prior to *Sphaerostilbe*. If the generic character assigned to the former is accepted, it will be necessary to retain both genera, and to transfer species from *Sphaerostilbe* to *Corallomyces*, when specimens of known species of *Sphaerostilbe* are collected which have developed perithecia on the old synnemata. And in that case both *Sphaerostilbe* and *Corallomyces* will be heterogeneous, for the latter must contain *Sph. repens*, with simple conidia, and *Sph. flammea*, with septate conidia, while the former will contain the parallel species, *Sph. aurantiaca* and *Sph. coccidophthora*. Alternatively, the misinterpreted generic character might be discarded, and all species of *Sphaerostilbe* referred to *Corallomyces*, but *Corallomyces* would still be heterogeneous.

The most logical course would appear to be to discard the false generic character of *Corallomyces*, and to include in the genus all species which are co-generic with the type specimen, *Corallomyces elegans*. The latter has *Nectria* perithecia, and a stilboid conidial stage with simple conidia, and is co-generic with *Sph. repens*, *Sph. variabilis*, *Sph. aurantiaca*, *Sph. gracilipes*, and *Sph. cinnabarina*. *Corallomyces* will then be equivalent to the first section of *Sphaerostilbe* of Tulasne, while the name *Sphaerostilbe* can be retained for those species which have a *Microcera* conidial stage and long septate conidia, viz. *Sph. flammea*, *Sph. aurantiicola*, and *Sph. coccidophthora*.

Corallomyces, Char. emend. Perithecia of *Nectria*; conidial stage stilboid; conidia continuous.

Sphaerostilbe, Char. emend. Perithecia of *Nectria*; conidial stage *Microcera*; conidia elongated, septate.

In re-describing *Microcera coccophila*, the Tulasnes stated that *Microcera* differed little from *Atractium* Link. Link established the genus *Atractium* in Magazin Gesellsch. Naturforsch. Freunde zu Berlin, Jahrg. III, 1809, p. 10, the type species being *Atractium Stilbaster*, and the generic characters, "Stroma elongatum, capitatum. Sporidia fusiformia, *non septata*, capitulo instrata." Link's figure shows a *Stilbum* with minute oval conidia; his type species is listed in Saccardo as *Atractium gelatinosum* (Pers.) Sacc. Subsequently (*ibid.* VII, p. 32) Link included in his genus *Atractium ciliatum* (*Tubercularia ciliata* Alb. and Schw.), with the note that he had seen septate conidia in this plant; the latter now stands as *Volutella ciliata*. Hence Link tacitly extended his genus to include species with septate spores, and in this he was followed by Berkeley and Saccardo, who published an amended generic description in Michelia, II, p. 32, citing *Atractium Therryanum* Sacc. as their type species. The genus *Atractium* would appear to require revision, but that is not relevant to the present discussion. The Tulasnes' statement is probably to be explained on the supposition that their knowledge of *Atractium* was based on the specimens sent to them by Berkeley as *Atractium flammeum* Berk. and Rav., since the latter species is identical with *Microcera coccophila* Desm.

Sphaerostilbe flammea Tul.

This species was described by the Tulasnes in 1856 as *Stilbum flammeum*, the name being changed to *Sphaerostilbe flammea* in 1861. Its conidial stage had been described by Berkeley in 1854 as *Atractium flammeum* Berk. and Rav. That *Sphaerostilbe flammea* is parasitic on scale insects appears to have escaped notice hitherto, though that is the case with all the specimens enumerated below. When its real host has been observed, the perithecial stage has been re-named, or the conidial stage has been correctly referred to *Microcera coccophila* Desm. (1848), which is identical with *Atractium flammeum* Berk. and Rav. (1854).

The fungus forms a white or pinkish tomentose or byssoid stroma, extending from or over the scale in many cases, but this is sometimes lacking. The synnemata (Plate III, fig. 8), in the North American and European forms, are usually small, either clavate, up to 0·6 mm. high and 0·25 mm. diameter, or conical, 0·5 mm. high, 0·25 mm. diameter, or, more generally, flattened pulvinate, up to 0·75 mm. long, 0·5 mm. broad. But

in tropical forms, they may attain a height of 2·5 mm. Both the stalked and sessile forms are usually clothed at the base with erect fascicles of hyphae arising from the basal stroma. The conidia are fusiform, straight, or straight with falcate tips, or slightly, but uniformly curved; they are up to eleven septate, but the septa are usually obscure, and frequently poorly developed, only two or three being present and those irregularly spaced; they measure 50–105 × 5–7 μ, as a rule, but sometimes are only 35 μ long. The short, curved, triseptate *Fusarium* conidium 18 × 4 μ, which is common in *Sphaerostilbe aurantiicola* (Plate V, fig. 11), has been observed in one American gathering.

The perithecia are crowded together on a well-developed stroma which often completely hides the scale insect (Plate III, fig. 7). They occur, in numbers up to about eighteen, in groups which may be a millimetre in diameter, and are usually at first partly covered by fascicles of hyphae arising from the stroma. When mature, they are bright orange red, darker round the ostiolum, glabrous, slightly rugose, opaque, globose, 0·3 mm. diameter, collapsing centrally as a rule; the ostiolum is minute, conical, acute, or scarcely evident. The cells of the perithecial wall are somewhat obscure, and the colour, by transmitted light, varies, according to the degree of maturity of the specimen, from yellow to red brown. The asci are cylindric, scarcely pedicellate, eight spored, spores obliquely uniseriate, 90–116 × 8–10 μ. Paraphyses are present, but diffluent. The ascospores are elliptic, ends obtuse, one-septate, not constricted, hyaline or yellowish, minutely verrucose, 12–19 × 5–8 μ.

The perithecial stage of this species was first collected by Ravenel in North America but the specimens were assigned by Berkeley to *Nectria muscivora* B. and Br. The latter species had been found at King's Cliffe, England, and had been described by Berkeley and Broome in Ann. Mag. Nat. Hist., Ser. 2, vol. VII, p. 188 (1851). It was parasitic on mosses. After their description, Berkeley and Broome added the note "We have this species from South Carolina on *Jungermanniae*." An examination of the type specimen of *Nectria muscivora* shows that it is not the same as Ravenel's species. *Nectria muscivora* has perithecia which have prominent papillaeform ostiola, and are embedded up to half their height, or up to the ostiolum, in a white floccose weft of mycelium; the perithecia are now amber coloured, the wall appearing hyaline by transmitted light; the ascospores are narrow oval to subfusoid, sometimes subcymbiform, with apices rounded or subacute, one-septate, rough, 15–24 × 6–8 μ; it is listed in Saccardo as *Calonectria*, but I was unable to find more than one septum in the spores of the specimen examined by me.

In 1854 (Ann. Mag. Nat. Hist., Ser. 2, vol. XIII, p. 461), Berkeley and Broome described a new species, *Atractium flammeum*. The type specimen was collected by J. Ralfs, on the bark of living willows, but the species was assigned to Berkeley and Ravenel, because it had been found "in similar situations, peeping up from beneath lichens," by Ravenel in South Carolina: it was described as "scarcely half a line high, cylindric, flame red, pruinose below, head convex, spores ·003 inch long, curved, fusiform, hyaline with six or more septa, seated on long sporophores." Berkeley and Broome added the note "Mr Ravenel in a late communication suspects it to be a state of some *Nectria*"; and on the herbarium specimens, Ravenel 1433 bears the note by Ravenel, "Can it be *Sphaeria muscivora* Berk.," while Ravenel 976 is marked by him "?*Sphaeria muscivora* Berk."

Ralfs's specimens in Herb. Kew, *ex* Herb. Berk. are "No. 90, *Atractium flammeum* Berk. and Rav., in Salix viva, Penzance," and "195, *Atractium flammeum* Berk. and Rav., in Fraxinum adhuc vivum, Penzance," with a drawing of the spore marked $\frac{1}{333}$. In Herb. B.M., *ex* Herb. Broome, there is a specimen from Ralfs, but it is marked "*Microcera coccophila* Desm., 468 *d*, on Willows, Penzance, January, J. Ralfs." None of these specimens is dated. In all the British specimens, the fungus is parasitic on *Chionaspis salicis*.

Of Ravenel's specimens, Herb. British Museum has, *ex* Herb. Ravenel, a specimen marked by Ravenel "*Atractium flammeum* Berk. and Rav. var. *minor*, S.C., Fasc. v, 80, Ravenel"; another with printed label, "86, *Atractium flammeum* Berk. and Rav. var. *minor*, ad corticem vivum Aceris"; "976, *Atractium flammeum* B. and R., Aest., ad Parmeliam, S.C., H.W.R."; "1433, *Atractium flammeum* B. and R., Feb., ad muscos, S.C., H.W.R."; "1843, *Atractium flammeum* B. and Rav., on *Acer rubrum*, S.C."; "1843, *Atractium flammeum* B. and Rav., on bark of living *Acer*, Aiken, S.C., H.W.R." Both 86 and 1843 contain perithecia.

In Herb. Kew, *ex* Herb. Berk., there are "(*Atractium flammeum* Berk. and Rav.), 976, *Sphaeria muscivora*? Berk. (in corticem non) on *Parmelia*, S.C., H.W.R.," the words in parentheses having been added by Berkeley; "(*Atractium flammeum* Berk. and Rav.), 1433, Feb., on mosses, *Frullania virginica*, S.C., H.W.R., Can it be *Sphaeria muscivora* Berk."; "1843, *Atractium flammeum* B. and R., on *Acer rubrum* (living trees), Aiken, S.C., H.W.R."; "No. 2958, *Stilbum*, Car. Inf."; and a packet, *ex* Herb. Cooke, bearing a label in Ravenel's handwriting "*Atractium flammeum* Berk. and Rav. var. *minor*."

All the foregoing specimens are the same, and are *Microcera*

coccophila Desm., while the perithecia are, as suggested by Ravenel, identical with the species referred by Berkeley to *Nectria muscivora* B. and Br. It may be noted that in Grevillea IV (1875), p. 47, Berkeley referred Ravenel 1843 to *Sphaerostilbe flammea* Tul., and, apparently, though the record is not clear, Nos. 976 and 1433, on *Parmelia* and *Frullania virginica*, to a "very distinct species on *Moquolia glauca*, Car. Inf. No. 5005 (*Atractium pallidum* B. and C.) which may possibly be the conidiiferous form of *Nectria muscivora*."

Berkeley sent specimens of *Atractium flammeum* to the Tulasnes, who described them as *Stilbum flammeum* in Acta hebdom. Acad. Sci. par., XLII, p. 704, and in Ann. Sci. Nat., Ser. IV, vol. V (1856), p. 114. They recorded the perithecial stage, but did not give the dimensions of the ascospore. In Selecta Carp. Fung. I, p. 130 (1861), they referred to it as *Sphaerostilbe flammea* (name only), while in vol. III, p. 104 of the same work (1865), they repeated their former description under the latter name. In the explanation of their plate, the Tulasnes stated that the description and figures were derived from an American specimen sent by Berkeley, though the fungus figured is said to be on "Saligni corticis frustrum," which is the supposed habitat of the European species. Their figure is not a good one, either of the perithecia or the conidial stage.

It is curious that the Tulasnes did not note that *Atractium flammeum* was identical with *Microcera coccophila* Desm. They did however state that *Microcera* did not differ from *Atractium* (Selecta Carp. Fung. I, p. 130). Specimens collected subsequently near Penzance were referred to *Microcera coccophila* by Broome, and later specimens from Ravenel bear the latter name.

Seaver's description of *Sphaerostilbe coccophila* (see p. 110) evidently refers to *Sphaerostilbe flammea*, and, of the specimens cited by him, Ellis, North American Fungi, No. 1333, and Ravenel, Fung. Car. Exsicc., No. 57, are *Sphaerostilbe flammea*. I have not seen Hume, Florida, No. 39.

Ellis and Everhart, North American Pyrenomycetes, p. 111, describe *Sphaerostilbe flammea* as having globose, bright red, nearly smooth perithecia crowded on or near the conidiophorous stroma; asci obovate oblong, eight-spored, sporidia ovate, obtuse, uniseptate, hyaline, slightly constricted, 12–16 × 5–6 μ; conidia 80–100 × 6·5, 6–9 septate. They cite the conidial fungus, Ravenel, Fung. Car. V. 86, which was issued as *Atractium flammeum* var. *minor*, and give the localities "on maple bark, Carolina (Ravenel)," and "on *Salix*, Louisiana, Langlois."

Seaver states that the ascospores of *Sphaerostilbe flammea* are elliptic to subfusoid, 15 × 6–7 μ. He cites the specimens Ellis

and Everhart, North American Fungi, 2nd Series, 3311; Langlois, 2290; Ellis, New Jersey; Dearness, Ontario, Canada.

Specimens which have been identified as *Sphaerostilbe flammea* Tul. are not numerous in British Herbaria, and many are incorrectly determined. Ellis and Everhart, North American Fungi, 2nd Series, No. 3311, *Sphaerostilbe flammea* Tul., and No. 3312, *Atractium flammeum* Berk. and Rav., are represented in Herb. B.M., but neither of these is correct. 3311 has densely clustered perithecia in cracks in the bark: the specimens are chiefly immature, and the available ascospores are narrow-oval or oblong-oval, 6–10 × 2–2·5. 3312 is a more immature gathering of the same species, and does not bear any *Atractium*.

Under *Sphaerostilbe flammea*, Herb. Kew has "Ravenel, Fung. Car. Exsicc., No. 5, 86," and "*Sphaerostilbe flammea* Tul., Rav. v, 86, sub *Atractium flammeum* v. *minor*, on *Acer*." The latter specimen is *ex* Herb. Cooke.

I have examined the following specimens of *Sphaerostilbe flammea* from Ravenel, which were referred to *Nectria muscivora*. Specimen *ex* Herb. Ravenel in Herb. B.M., marked "45, *Sphaeria muscivora* Berk., Nov., on *Jungermannia* growing on *Acer rub.*, S.C., H.W.R."; this has synnemata clavate, 0·5 mm. high, 0·05 mm. diameter below, expanding to 0·25 mm. above, or pulvinate, 0·5 × 0·25 mm.; conidia 60–80 × 5–6 μ, nearly straight, up to nine-septate, septa obscure and poorly developed, usually only three or four and irregularly distributed; conidia tend to collapse laterally; ascospores 12–19 × 6–8 μ. Specimen *ex* Herb. Ravenel in Herb. B.M., marked "45 *Sphaeria muscivora* Berk., Autumno, apud *Jungermannia*, S.C., H.W.R.," with drawing of ascospore marked "·0007 inch long"; apparently a duplicate of the former; both contain many synnemata but few perithecia. Specimen *ex* Herb. Ravenel in Herb. B.M., marked 1156 and spore measurement as above; this has caespitose collapsed perithecia. Ravenel, Fungi Car. Exsicc., No. 57, in Herb. Kew and Herb. B.M.; ascospores 13–17 × 6–8 μ. Specimens in Herb. Kew and Herb. B.M., *ex* Herb. Ravenel, "3263, *Nectria muscivora* Berk., on moss on *Acer*, St Johns (indecipherable), S.C., Apr. 81, H.W.R."; perithecia clustered in groups up to 1 mm. diameter, orange red, collapsing centrally, darker round the ostiolum, pruinose with white granules; ascospores 12–17 × 7–8 μ; synnemata flattened pulvinate up to 0·6 × 0·4 mm., or clavate, 0·6 mm. high, 0·25 mm. diameter; conidia nearly straight, 85–105 × 6 μ, up to eleven septate, septa obscure; conidia fairly abundant; the pulvinate synnemata bear numerous developing perithecia. Specimen in Herb. Kew, marked "*Nectria muscivora*, Car. Aust." which is apparently part of one of the Ravenel specimens with *Jungermannia*.

Specimen in Herb. Kew, marked "99, *Nectria muscivora*, on mossy trees, Apr., H.W.R., Houston, Texas."

The following Ravenel collections were correctly assigned to *Microcera coccophila*. Specimens in Herb. Kew and Herb. B.M., "Ravenel 2527, *Microcera coccophila* Desm., on living *Rhus*, Darien, Ga." Specimens in Herb. Kew and Herb. B.M., *ex* Herb. Ravenel, "3376, on exposed root of Water Oak, Darien, Ga., Nov. 81"; these appear to be the same gathering as "Ellis, N.A. Fungi, No. 1229, *Microcera coccophila* Desm., on bark of *Quercus* (? *palustris*), Darien, Ga., H. W. Ravenel," of which there is a specimen in Herb. B.M.; the sporodochia are pulvinate, oval or circular, up to 0·75 × 0·5 mm., sometimes confluent; conidia 75–80 × 5–6 μ, obscurely septate; a small curved *Fusarium* conidium, three septate, 18 × 4 μ, is present; some of these specimens bear clustered perithecia, with ascospores 14–17 × 6–7 μ.

Sphaerostilbe flammea was described as *Nectria laeticolor* by Berkeley and Curtis in Journ. Linn. Soc., x. (1868), p. 377, on specimens from Cuba, "on trees among hepatics." It is on a scale insect. Berkeley and Curtis cite the numbers 458, 542, 555. Specimen 458 is missing in Herb. Kew: the sheet is marked by Berkeley, "immature." 542 and 555 are *Sphaerostilbe flammea*, sometimes with perithecia on the synnemata. Specimens distributed as "765 Fungi Cubenses Wrightiani" are part of these gatherings. *Nectria laeticolor* is cited by Seaver as a synonym of *Sphaerostilbe flammea*. There is another Cuban specimen of *Sphaerostilbe flammea* among the unnamed *Dubiae* in Herb. Kew, apparently from Curtis.

Berkeley and Curtis subsequently, in Grevillea, iv, p. 45 (1875), described the same species as *Nectria aglaothele*, stating that it grew on the remains of a coccus. The type specimen of *Nectria aglaothele* in Herb. Kew is marked by Berkeley, "Sprague, on Alder, New England, No. 5378"; its ascospores are 13–17 × 6–8 μ. There are apparently duplicates of this collection in Herb. B.M. *ex* Herb. Bloxam, and in Herb. Kew *ex* Herb. Cooke and Herb. Currey, all marked by Berkeley "*Nectria muscivora* Berk., on alder, Mass." It would seem that Berkeley had discovered, after distributing the duplicates, that the American specimens which he had assigned to *Nectria muscivora* had been incorrectly determined.

In Grevillea, iv, p. 47 (1875), Berkeley recorded "*Sphaerostilbe coccophila* Tul., on *Alnus serratula*, Pennsylvania, Michener, No. 4316." The specimen in Herb. Kew is marked "4316, *Sphaerostilbe coccophila* Tul., *Atractium coccigena* B. and C., on *Alnus serratula*, Penn., Michener." It is *Microcera coccophila* Desm., the conidial stage of *Sphaerostilbe flammea*.

In 1882, Saccardo and Ellis (Michelia, II, p. 570) described this species as *Nectria subcoccinea* Sacc. and Ellis. Specimens were distributed by Ellis in North American Fungi, No. 1333, on bark of living alder, West Chester, Pa., October 1881, Everhart and Haines. In Ellis, 1333 in Herb. Kew and Herb. B.M., the perithecia are globose, clustered, with a minute conical ostiolum; the asci are 100–116 × 8 μ, cylindric, spores uniseriate or obliquely uniseriate; ascospores 13–18 × 6-7 μ; the synnemata are conical, 0·35 mm. high, 0·25 mm. diameter, clothed below with erect fascicles of hyphae, or pulvinate, 0·5 × 0·25 mm.; the conidia are nearly straight, or curved at one end, up to six septate, 35–45 × 5–6 μ. This example has unusually short conidia.

Ellis and Everhart, in North American Pyrenomycetes (1892), stated that *Nectria subcoccinea* Sacc. and Ellis was identical with the Ravenel specimens in Fungi Car. Exsicc., I, No. 57, which Berkeley had assigned to *Nectria muscivora*, and they drew up their description of the latter species from the specimens, Ellis, North American Fungi, No. 1333, which had been issued as *Nectria subcoccinea*. They noted that neither Ravenel's specimens nor Ellis 1333 showed anything of the white lanose patches mentioned in the original description of *Nectria muscivora*, but they nevertheless retained Berkeley's identification.

In Grevillea, IV, p. 45 (1875), Berkeley described a *Nectria* as *Nectria viticola* B. and C. This, according to von Höhnel and Weese in Herb. Kew, is *Nectria sanguinea*. It is not on a scale insect. But Passerini, in 1875, found a *Nectria* on *Vitis vinifera* in Liguria, which he referred, in Pirotta, Fung. Vit. VII, p. 45, to *Nectria viticola* B. and C. He sent specimens to Kew, labelled "*Nectria viticola* B. and C., Grevillea, Dec. 1875, nisi abstent conidia fusiformia, Ropallo, Liguria, ad sarmenta viva vitis vinifera, Iunio 75, G. Passerini." Cooke recognised that this was not the same as Berkeley and Curtis's species, and described it in Grevillea, XII, p. 81, as *Nectria Passeriniana* Cke. The specimen in Herb. Kew is marked by von Höhnel and Weese, "*Nectria viticola* Pass. = *Endothia* (?) *Passeriniana* (Cooke) Weese. *Hypocreopsis*??." This is a clustered *Nectria* with a well-developed stroma, covering a scale insect. Its ascospores are up to 18 × 8 μ. It has minute pulvinate synnemata and *Microcera* conidia. There is no doubt that this is *Sphaerostilbe flammea*.

A specimen from E. W. Berger, on scale of oak (*Chrysomphalus obscurus*), Florida, in Herb. British Museum, sent as *Sphaerostilbe coccophila* Tul., is *Sphaerostilbe flammea*. The ascospores are 13–18 × 7–8 μ; the synnemata are flattened pulvinate; the conidia are 75–80 × 5–6 μ, nearly straight, or

straight with falcate tips, up to nine-septate with well-defined septa.

Prof. C. Spegazzini has kindly forwarded me specimens of this species, on a scale insect on pine needles (locality?) January 20, 1916, and La Plata, May 19, 1919, under the MSS. name, *Nectria coccicida*. In these the synnemata may be clavate, up to 0·6 mm. high, 0·12 mm. diameter at the base, 0·25 mm. diameter above (Plate III, fig. 8), but the majority are conoid, up to 0·5 mm. high, 0·3 mm. diameter, or flattened pulvinate, up to 0·4 mm. long, 0·2 mm. broad, and 0·25 mm. high; they are situated on, or at the side of, the scale, and usually arise from a well-developed stroma; the conidia are straight, or straight with falcate tips, or uniformly curved, pale yellow under a low magnification, hyaline when more highly magnified, up to nine-septate, ends obtuse, 80–88 × 6–7 μ. The asci measure 90–110 × 9–10 μ, and the ascospores, 13–17 × 6–8 μ.

Microcera coccophila Desm., "No. 1350, Plantes Cryptogames de France, Ed. II, Ser. 1, 1836–51," specimen in Herb. B.M., has synnemata flattened pulvinate or discoid, with a rather broad whitish margin, up to 0·6 mm. diameter, or conical, up to 0·6 mm. high, 0·3 mm. diameter below, or clavate, with erect fascicles of hyphae at the base; the sheath divides above into separate hyphae; the conidia are scanty, 50–80 × 5–6 μ, almost straight, fusoid, with obscure septa up to nine. This specimen also bears clustered perithecia on a well-developed stroma; the developing perithecia are orange, covered with fascicles of hyphae from the stroma; the mature perithecia are red; the ascospores are 12–18 × 5–7 μ.

Both Herb. B.M. and Herb. Kew have *Microcera coccophila* Desm., "No. 1750, Plantes Cryptogames de France, Ed. 1, Ser. 1, 1825–51"; this has some of the synnemata cylindric, up to 0·7 mm. high, 0·2 mm. diameter.

Conidial specimens from Penzance, the type locality of *Atractium flammeum* Berk. and Rav., when collected in later years, were referred correctly to *Microcera coccophila* Desm. In Herb. B.M., there are specimens *ex* Herb. Broome, *Microcera coccophila* Desm. (1) Trengwainton, Penzance, 14 Dec. 1869; (2) nr. Penzance, Dec. 1869; (3) Trengwainton, 4 Dec. 1869, marked "early stage of *Nectria Ralfsii*?." It is not related to *Nectria Ralfsii*. Specimen 1 shows the developing perithecia of *Sphaerostilbe flammea*. Herb. B.M. also has Cooke 350 and 534, and duplicates from Herb. Cooke.

Herb. Kew has, under *Microcera coccophila* Desm., a specimen *ex* Herb. Berkeley, marked "Penzance, C.E.B., Dec. 1869," containing minute synnemata on a well-developed stroma; Cooke, Fungi Brit. Exsicc., No. 350 (two examples); Cooke, Fungi

Brit. Exsicc., Ed. II, No. 534, C. E. Broome (two examples); and duplicates *ex* Herb. Cooke. Cooke's specimens are generally poor; some are not localised or dated; others are marked, "near Penzance, 14 December, 1869," "Penzance, Dec. 1869, C. E. Broome," and "Cornwall, Jan. 1870, C. E. Broome," respectively.

In the cover of *Myriangium Duriaei* in Herb. B.M., there is an undated specimen, marked "near Ryde, Isle of Wight, A.B." In addition to the *Myriangium*, this bears *Microcera coccophila*.

A specimen, *ex* Herb. Cooke, under *Microcera coccophila* Desm. in Herb. Kew, is marked "*Atractium coccigena* B. and C., Cort. Persicae, Ludoviciana." There is very little left of the fungus, but it is apparently *Microcera coccophila*. I am indebted to Mr Grove for the suggestion that the locality is Louisiana.

Of the specimens cited by Ellis and Everhart in "North American Pyrenomycetes" as *Sphaerostilbe coccophila* Tul., that on *Alnus serratula* from Pennsylvania is, as already stated, *Sphaerostilbe flammea*, while Ravenel, Fungi Americani, No. 286 is *Sphaerostilbe aurantiicola*.

Microcera pluriseptata Cke. and Massee was described in Grevillea, XVII, p. 43, as occurring on *Calocera* and bark, in Mexico. The type specimen in Herb. Kew was originally endorsed by Berkeley "Brazil, Cordova, Salle," but Cooke crossed out Brazil and substituted Mexico. The fungus is on a scale insect, and the supposed *Calocera* consists of the almost effete synnemata, which are up to 2·5 mm. high. The conidia are 75–90 × 5–7 μ, five- to seven-septate, but with somewhat obscure septa; they tend to collapse laterally. Perithecia occur on the scale insects and on the old synnemata; they are typical *Sphaerostilbe flammea*, with ascospores 13–17 × 7 μ, oval, pale yellow. *Microcera pluriseptata* Cke. and Massee is consequently a synonym of *Microcera coccophila* Desm.

Fusarium coccinellum (Kalch.) Thuem., *Fusisporium coccinellum* Kalch., was described by Kalchbrenner in Fungi Austro-Africani, Flora, LIX (1876), p. 426, and issued by de Thümen, Mycotheca Universalis, No. 782, the specimens being from the Cape of Good Hope. It is on a scale insect. In the specimens, Thuemen 782, in Herb. Kew and Herb. B.M., the synnemata are clavate, 1·25 mm. high, 0·25 mm. diameter below, expanding to 0·5 mm. diameter above, or shortly stalked, with flattened globose heads up to 0·75 mm. diameter, or sessile and pulvinate. The conidia are 74–80 × 5–6 μ, almost straight, or straight with falcate tips, or slightly curved, obscurely septate, with up to nine septa. As noted by Kalchbrenner, the base of some of the sessile forms swells strongly in water. The specimens were

collected by P. MacOwan at Somerset East, on *Acacia horrida*, the collection number being 1059. There is a part of this collection in Herb. Kew, "Kalchbrenner No. 1059, on *Acacia horrida*, Cape," determined by Cooke as *Sphaerostilbe flammea conidiophora*, while another part, also in Herb. Kew, is labelled in an unknown handwriting, "*Sphaerostilbe flammea* Tul., Cap. b. sp., leg. MacOwan, No. 1059, comm. $\frac{9}{83}$. Type of Kalchbrenner." Herb. Kew has also a specimen, *ex* Herb. MacOwan, marked "1064, *Nectria haematococca* B. and Br., ad corticem *Acaciae horridae*" which was also referred to *Sphaerostilbe flammea* by Cooke; it is the same as the other specimens and does not contain perithecia. No perithecia have been observed in this gathering, but it appears to be *Microcera coccophila* rather than *Microcera aurantiicola*.

In Herb. Kew, there are specimens, *sub Microcera coccophila*, from New Zealand—Rev. W. Colenso, B. 82, on bark of *Alectryon excelsum*; Colenso, B. 919; and Colenso, B. 727. These are large forms, with synnemata up to 2·25 mm. high, 0·6 mm. diameter. The conidia are 75–85 × 6 μ, straight with acute tips, or straight with slightly falcate tips, or slightly uniformly curved, up to nine-septate, with well-developed septa. No perithecia have been observed, but from the shape of the conidia, the specimens would appear to have been referred correctly to *Microcera coccophila*.

Herb. B.M. has the Australian specimen from Bailey, *ex* Herb. Broome, referred to by McAlpine under *Microcera coccophila*. It is marked, Brisbane, F. M. Bailey, No. 383, and contains well-developed synnemata on a scale insect on leaves and stem of Citrus. The conidia are 75–100 × 6 μ, up to nine-septate, with well-developed septa; some have falcate tips, but the majority are fusoid and straight. It would appear to be correctly named.

Sphaerostilbe aurantiicola (B. and Br.) Petch.

This species was described by Berkeley and Broome, as *Nectria aurantiicola*, in Fungi of Ceylon, No. 1028, their description being—"Peritheciis aurantiacis in stromate erecto sitis; ascis clavatis; sporidiis ellipticis uniseptatis, sporisque fusuloideis (No. 190). On orange twigs. Sporidia 15 μ long, 7·5 μ wide; spores fusiform, curved, multiseptate, 92 μ long; others triseptate and strongly curved, 20 μ long. Apparently growing from some Coccus."

The type specimen in Herb. Kew, *ex* Herb. Berkeley, is now very poor. Better specimens are to be found in Herb. British Museum, *ex* Herb. Broome. The following description has been drawn up from Ceylon specimens which agree with the types.

The synnemata arise from a narrow, yellowish-white, loose weft of hyphae at one side of, or surrounding, the scale. They are orange-red, or pinkish-red with a blood-red head, generally erect, clavate, expanding into an ovoid head (Plate III, fig. 1), or with a cylindrical stalk and a subglobose head, or uniformly cylindric. Small specimens are about 0·8 mm. high, 0·15 mm. diameter below, expanding into a head, 0·3 mm. diameter, but they may attain a height of 2 mm., with a stalk 0·4 mm. diameter and a head 0·6 mm. diameter. Several may arise from the same scale, and adjacent synnemata may fuse laterally into a broad band. The stalk is sometimes smooth, but more usually longitudinally fibrillose, especially at the base. When fresh, the fructification is subtranslucent: when dry, it is hard and horny, and, while the smaller specimens may retain the blood-red colour of the head, the larger become a nondescript brownish red or reddish yellow. Some specimens are almost sessile, clavate or ovoid. The head is often laterally compressed, and often hooked or produced laterally into a point.

The outer layer of the stalk hyphae forms a continuous sheath which divides above into long triangular teeth, about 120 μ long and 16 μ broad at the base. In small specimens, these teeth may converge at the apex of the head, but in the larger they are adherent to its sides. The outer sheath hyphae are about 4 μ diameter, equal, septate, and united by ladder connections. The interior stalk hyphae are continued above as branched conidiophores, 3 μ diameter, with long branches. Ladder connections are common between the bases of the conidiophores.

The conidia are cylindric, tapering towards the ends (Plate V, fig. 10), or long fusoid, straight, or slightly curved at the ends, hyaline, multiseptate. Under a low power they have a distinct yellow tinge. Up to eleven septa have been counted, but nine is more usual. The two ends of the spore are not equally curved; the distal end is slightly and uniformly curved and terminates in an obtuse point, while the proximal end is more falcately curved and more acute. A few uniformly curved conidia, of the same length, may sometimes be found. Measurements of the conidia from different gatherings are 88–110 × 6–7 μ; 90–116 × 6–7 μ; 80–112 × 6–7 μ; 84–104 × 7 μ; 96–120 × 5–6 μ; 90–120 × 6–7 μ; 70–92 × 5–6 μ.

In addition to the conidia described above, a smaller, more curved conidium (Plate V, fig. 11) is found in some gatherings. It was noted by Berkeley and Broome, and has been observed in five recent collections, including one from Dominica. It does not occur in the head with the long conidia, but on the looser mycelium at the base of the stalk. Sometimes it is found at the base of the perithecium, although there may be no conidial

fructification evident there under a magnification of forty diameters. This conidium is strongly curved, up to two-thirds of a circle, fusoid, hyaline, one- to three-septate, with obtuse tips, 12–16 × 4 μ, measured from tip to tip, not round the curve.

The perithecia (Plate III, fig. 3) are situated round the scale, scattered or clustered, with no evident stroma, but usually attached by a few inconspicuous radiating hyphae. As a rule, they occur round scales which do not bear the conidial synnemata. But, as noted by Berkeley and Broome, perithecia also occur at the base of the synnemata, or along their stalks, or even among the conidiophores in the head. This however only occurs on the larger synnemata, and even on those it is not the rule. I have only one collection in which this occurs, and in that the perithecia on the synnemata are immature. Parkin illustrates this position of the perithecia in his figure 9.

The perithecia are smooth, or pruinose with a few yellow granules, subsequently becoming smooth, very minutely rugose when highly magnified, 0·2–0·25 mm. diameter, subglobose, with a broad papillate ostiolum, or subconoid, scarcely papillate (Plate III, fig. 4). They are usually orange-red, becoming blood-red or dark red, and subtranslucent, but immature examples may be orange-yellow. The latter may account for Berkeley and Broome's "aurantiacis," but it is more probable that they gave the colour of the wall by transmitted light. In old examples, the wall, when mounted, is red-brown, but younger examples show an orange-yellow wall, though viewed as opaque objects they are orange-red. This is a common phenomenon in red Nectrias in the tropics. The cells of the perithecium wall are thick-walled and up to 12 μ diameter, though the structure is usually obscure. The ostiolum is fimbriate.

The asci are cylindrico-clavate, scarcely pedicellate, eight-spored, with diffluent paraphyses with granular contents. The spores may be uniseriate, or obliquely uniseriate, or obliquely uniseriate above and uniseriate below. The dimensions of the asci in different gatherings are 72–80 × 6–7 μ; 70–80 × 7 μ; 70–88 × 6 μ; 66–74 × 7–9 μ; 70–90 × 7–8 μ; 74–80 × 7 μ; 70–80 × 7–8 μ.

The ascospores are oval, or broadly oval, ends obtuse, hyaline, becoming yellowish, wall rather thick and minutely warted, one-septate, not constricted at the septum, except slightly in old extruded spores. Their dimensions in different collections are, 9–12 × 5–6 μ; 10–12 × 4–5 μ; 11–13 × 5 μ; 9–13 × 5–6 μ; 11–13 × 5–6 μ; 10–14 × 5–6 μ; 10–14 × 4–6 μ.

I have the following recent collections of this species. On *Diaspis pentagona* on *Flacourtia Ramontchi*, Ceylon. On *Aspidiotus aurantii* on Rose, Ceylon. On *Aspidiotus aurantii* on

Citrus, Ceylon. On *Aspidiotus aurantii* on Mulberry, Ceylon (five collections). On *Aspidiotus* sp. on *Cycas*, Ceylon. On a diaspid (?) on *Thespesia*, Ceylon. On *Mytilaspis citricola* on *Citrus*, Ceylon (three collections). On ? *Porococcus*, on Palmyra, Ceylon. On *Lepidosaphes* sp. on Pepper (*Piper nigrum*), South India (C. A. Barber, 1905). On *Lepidosaphes* sp. on *Citrus*, Madagascar. Conidial stage on *Aspidiotus* and *Lepidosaphes*, and perithecial stage on *Lepidosaphes*, on *Citrus*, Dominica.

In the specimen from Dominica, the synnemata are small, and the conidia measure only 70–92 × 5–6 μ: most of them are three-septate, a few five-septate. The asci are 74–80 × 7 μ, and the ascospores 10–14 × 4–6 μ. The perithecia are identical with the Ceylon form of *Nectria aurantiicola*, and the small, curved *Fusarium* spores occurred with them.

A *Sphaerostilbe*, parasitic on scale insects in Japan and Formosa, has been recorded, with some doubt, by Miyabe and Sawada, as *Sphaerostilbe coccophila* Tul. I have been able to examine the following specimens, *ex* Herb. Sapporo.

On a scale on apple trees, Tsukisappu near Sapporo, October 5, 1907. In this, some synnemata are suberect, with a short stout stalk, 0·2 mm. diameter and 0·4 mm. high, expanding into an ovoid head, 0·3 mm. diameter, and 0·4 mm. high, pointed above; the stalk in these is dark red, subtranslucent, and the head pale yellowish, the latter colour being due to the disappearance of most of the conidia. Other synnemata are almost sessile, ovoid, or sometimes merely pulvinate, dark red. The sheath divides above into teeth, but the teeth break up above into separate hyphae, as a rule, as long as, or longer than, the conidiophores. The conidia measure 84–100 × 5–7 μ, and are up to nine-septate, nearly straight or curved at the tips, one end more obtuse than the other. When examined under a low power the conidia are distinctly yellowish.

In another gathering, on a coccid on *Ficus Wightiana*, Sozan, Formosa, May 1911, the synnemata are mostly stalked, but the heads have been eaten off by insects.

In a collection, on coccids on *Citrus nobilis*, Shimpo, Formosa, May 7, 1910, the synnemata are generally small, pulvinate, blood-red masses at the side of the scale, sometimes several confluent and forming a fringe at one end.

Similar synnemata occur on scale insects on *Citrus nobilis*, Taihoku, Formosa, April 25, 1911. Some of the sessile pulvinate synnemata are up to 0·4 mm. long and 0·2 mm. broad. Stalked forms, with stalks up to 0·3 mm. high and 0·2 mm. diameter, also occur in this gathering. The conidia are 80–96 × 6–7 μ.

Perithecia appear to be rare in the Formosan collections. Miyabe and Sawada state that they have only found them once,

on Tea, Taihoku, Sozan, May 1911. I have seen a leaf of that gathering, which bore one perithecium, not quite mature. It was subconoid, 0·15 mm. diameter, orange-red, slightly pruinose with yellow granules, seated on the scale without any evident stroma. No mature asci were found, but two loose ascospores were observed, measuring $10 \times 3\,\mu$ and $12 \times 5\,\mu$ respectively; Miyabe and Sawada state that the ascospores measure $8–10 \times 4–5\,\mu$.

On the available specimens, the Japanese and Formosan forms would appear to be referable to *Sphaerostilbe aurantiicola*.

In Herb. British Museum, there are the following specimens from Florida, communicated by E. W. Berger;—(1) on *Aspidiotus perniciosus*, San José Scale, on Peach, all conidial; (2) on *Chrysomphalus aonidium*, Florida Red Scale of Citrus, on *Citrus*, two conidial specimens; (3) on *Lepidosaphes beckii*, Purple Scale of Citrus, one specimen containing the conidial stage and scattered perithecia with ascospores $10–13 \times 5–6\,\mu$.

As pointed out under *Sphaerostilbe coccophila*, the specimens collected at Florence in 1860, which furnished the perithecial examples of that species are *Sphaerostilbe aurantiicola*. These are represented in British herbaria by the following.

"No. 262, Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda. *Nectria episphaeria* Tode. Ad *Lauri* corticem in horto Boboli Florentiae, Majo 1860, leg. L. Caldesi." Specimens in Herb. Kew and Herb. B.M. The bark is densely covered with scale insects. The perithecia are usually scattered without evident stroma, sometimes clustered, orange-red becoming dark red, conoid, usually collapsing laterally; apex darker, conical, or papillate; asci $65–75 \times 7\,\mu$; ascospores $9–14 \times 4–5\,\mu$; perithecial wall red-brown by transmitted light. Small curved triseptate spore rather common, $14–18 \times 3–3{\cdot}5\,\mu$. Synnemata appear to be absent.

"No. 269, Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda. *Microcera coccophila* Desm. Florence, ad corticem *Lauri* in horto Boboli dicta, Majo 1860, leg. L. Caldesi." Specimens in Herb. Kew and Herb. B.M. A poor development on scattered scale insects. Synnemata pulvinate; conidia $75–85 \times 6\,\mu$, few in comparison with the number of conidiophores; septa up to nine, but usually few and obscure. Perithecia immature, orange-red, subtranslucent, scattered or in small clusters, wall yellow when mounted.

"No. 543, Erbar. Crittogam. Ital., *Microceras coccophila* Desm., Sull' Alloro nel giardino di Boboli a Firenze, Aprile 1860, Caldesi." Specimen in Herb. B.M.; resembles Rabenhorst 262, and Erbar. Crittogam. Ital. 539; contains chiefly developing *Nectria*. Synnemata flattened pulvinate, circular, 0·4 mm. diameter, or clavate, 0·75 mm. high, 0·25 mm. diameter; conidia scanty,

80 × 6 μ, almost straight with one end falcate, or slightly curved.

"No. 539, Erbar. Crittogam. Ital., *Nectria episphaeria* Fr., Sull' Alloro nel giardino di Boboli a Firenze, Maggio 1860, Caldesi." Specimen in Herb. B.M. ? same collection as Rabenhorst 262. Apparently no synnemata. Small curved *Fusarium* spore present, 18 × 3·5 μ. Perithecial wall red-brown when mounted; ascospores 10–12 × 4 μ.

The foregoing are apparently all parts of the same growth of the fungus. Another collection was made in the same locality six years later, "No. 542, Erbar. Crittogam. Ital., Ser. II, *Sphaerostilbe coccophila* Tul., Sull' Alloro nel giardino di Boboli a Firenze, 1866, Caldesi," of which there is a specimen in Herb. B.M. A narrow, yellowish byssoid stroma surrounds the scale. The synnemata are flattened pulvinate, up to 0·6 mm. long, 0·4 mm. broad, and 0·2–0·3 mm. thick, flesh-coloured, with a narrow white or yellowish tomentose margin, or erect, subcylindric or clavate, up to 0·75 mm. high, 0·3 mm. diameter; few conidia are present, and these are found among the conidiophores; the conidia are nearly straight with slightly falcate tips, 60–75 × 5–6 μ, up to seven-septate, with obscure septa: some conidia are strongly guttulate. On one effete cylindric synnema, the sheath persisted as a hyaline membrane. The immature perithecia are orange-red, mature perithecia red; they are situated in small groups on the marginal stroma, or sometimes on the synnemata; the ascospores are 9–12 × 4–5, a few 14–15 × 6 μ. The short curved *Fusarium* spore is present.

In Herb. Kew and Herb. B.M., there are American specimens *ex* Herb. Ravenel, under *Microcera coccophila*, "No. 2512, in corticis Mori, Darien, Georgia." This gathering appears to be the same as "No. 286, H. W. Ravenel, Fungi Amer. Exsicc., *Microcera coccophila* Desm. in corticis *Mori*, Darien, Georgia," of which there is a specimen in Herb. B.M. The synnemata are clavate, up to 1 mm. high, 0·4 mm. diameter, or flattened pulvinate, up to 1 mm. long and 0·6 mm. broad; the conidia are 56–80 × 5–6 μ, obscurely septate, with a few irregularly-arranged septa. The small curved *Fusarium* spore, 18 × 3 μ, is present. The ascospores are 9–12 × 4–5 μ. This specimen is *Sphaerostilbe aurantiicola.*

Sphaerostilbe coccidophthora (Zimm.) Petch.

This species was described by Zimmermann, as *Nectria coccidophthora*, from specimens on *Lepidosaphes* sp. on *Coffee arabica*, and on *Parlatoria zizyphi* on *Citrus*, found at Buitenzorg, Java. The following are the main details of his description.

The conidial fructification was scarlet (mennig-rot), shortly stalked, and swelled considerably in water. The stalk was 0·3–0·4 mm. long, and the head, 0·4–0·45 mm. long. The

conidia were surrounded by hairs, which were united laterally by ladder connections and converged above. The conidia were hyaline, cylindric, slightly curved at the tips, six- to eight-septate, 110–120 × 6 μ.

The perithecia were clustered at the base of the conidial fructification, or scattered over the stroma which permeates the insect. They were globose, carmine-red, with a papillate, somewhat paler ostiolum, 280 μ high and 230 μ diameter. The asci were eight-spored, 100 μ long. The spores were one-septate, hyaline, obtuse, not constricted, 17–20 × 7–8 μ.

Zimmermann compared his species to *Nectria aurantiicola* B. and Br., from which he decided it differed in the colour of the perithecia, and the form of the conidial fructification, according to the figures given by Berkeley and Broome. His figure of the conidia shows spores of the *Microcera* type, not *Pseudomicrocera*.

The only other record of this species appears to be that of Parkin, who assigned all the Ceylon *Microcera* forms to *Nectria coccidophthora*. Parkin's measurements of asci and ascospores appear to be from specimens of *Nectria coccidophthora*, but his figures of synnemata and conidia (9, 10, 11) are *Nectria aurantiicola*. Of Parkin's specimens which are now available, that on *Chionaspis biclavis* on *Tabernaemontana* is *Nectria coccidophthora*, and probably that on *Asterolecanium miliaris* on Bamboo, while, from his description, that on *Chionaspis biclavis* on Tea was the same species.

I have collections of what appears to be undoubtedly this species, on *Chionaspis biclavis* on Tea, Ceylon (two gatherings), on *Chionaspis* on an undetermined host plant, Ceylon (two gatherings), on *Chionaspis biclavis* on *Tabernaemontana*, Ceylon (Parkin's specimen), on *Chionaspis*, on an undetermined host plant, India (E. J. Butler), and on *Diaspis pentagona* on *Flacourtia*, Seychelles. It is noteworthy that, of the seven collections six are on *Chionaspis*.

The synnemata arise from a narrow, yellowish-white, loose, floccose stroma, or weft of hyphae, round the scale. They are orange-red or scarlet, paler towards the base, generally erect, usually clavate, expanding into an ovoid head. As a rule, they are not as stout as those of *Nectria aurantiicola*, being commonly about 0·8 mm. high, with a stalk 0·15 mm. diameter, and a head 0·3 mm. diameter, but sometimes examples occur which attain a height of 1·4 mm., and a stalk diameter of 0·25 mm. The stalk is generally longitudinally fibrillose. When fresh, the synnemata are subtranslucent, and become hard and horny when dry. Specimens in which the stalk is almost wanting are not uncommon; these may be ovoid, or conical, about 0·4 mm. high, and 0·25 mm. diameter. As in *Nectria aurantiicola*, the head is often curved to one side. The structure of the synne-

mata is identical with that of *Nectria aurantiicola*. The small, curved, *Fusarium* spores which occur in the latter have not been observed in *Nectria coccidophthora*, nor have developing perithecia been observed on its stalk above the base.

The conidia are cylindric, or long fusoid, almost straight, slightly curved at the ends, hyaline, multiseptate. Up to eleven septa have been counted, but the most common numbers are six to nine. In the usual gathering, however, large numbers of immature, unseptate conidia are met with. In shape, they agree with those of *Sphaerostilbe aurantiicola*, but the tips are sometimes slightly more curved. Septation begins at the distal end, and it is not uncommon to find conidia which have developed two or three consecutive septa at that end, before any are visible elsewhere. Measurements of the conidia from the different collections gave the following dimensions: 76–93 × 6 μ; one 62 × 6 μ; 78–96 × 6–7 μ; 88–98 × 6 μ; 88–106 × 6–7 μ; the total variation is 62–106 × 6–7 μ. The conidia agree in shape with Zimmermann's figure, but I have not met with any 110–120 μ long. In the available collections, the conidia of *Sphaerostilbe aurantiicola* usually attain a greater maximum length than those of this species.

The perithecia may be scattered, or clustered in groups up to ten. They are sometimes situated at the bases of the synnemata, but in general they are found on scales which do not bear any conidial fructification. They may be seated on a narrow floccose stroma round the scale, or the stroma may completely cover the scale, and the perithecia may be scattered over it. On the other hand, they may arise at the margin of the scale without any visible stroma.

The perithecia are subglobose or subconoid, 0·2–0·3 mm. diameter, collapsing laterally, orange-red at first, becoming blood-red, subtranslucent, covered with minute yellow, or yellowish-red, granules except round the ostiolum (Plate III, fig. 6). Weathered specimens lose the granular covering, and are blood-red to dark red, but when magnified the area round the ostiolum is evidently smoother than the rest of the wall. The shape of the ostiolum is highly variable: as a rule, it is slightly papillate, with a flat papilla about 60 μ diameter, but in some specimens the apex is merely obtusely conical. In one gathering, on *Chionaspis*, a few of the perithecia have the ostiolum produced and cylindrical, up to 96 μ high and 106 μ diameter, but in other examples on the one scale they are simply slightly papillate. This variation makes it impossible to separate the scale insect Sphaerostilbes on the shape of the ostiolum. The wall, viewed by transmitted light, is orange-yellow in immature, or young, examples, but red-brown in old specimens. The structure is generally obscure, but in some cases thick-walled

cells, up to 10 μ diameter can be recognised. The wall bears projecting cells, or one-septate processes, sometimes growing from the cells of the wall, and sometimes appearing to be merely fastened to it by a yellow substance. The ostiolum is fimbriate. When detached, the perithecium usually has a minute, and somewhat compact, mass of mycelium at the base.

The asci are cylindrico-clavate, i.e. cylindric, slightly attenuated below, and usually shortly pedicellate. They are accompanied by long, linear paraphyses, which disappear before the asci are mature; the paraphyses have granular contents. The asci are eight-spored, and the spores slightly obliquely uniseriate. Measurements of the asci from different collections gave 105–115 × 9–10 μ; 100–106 × 10 μ; 100–110 × 10 μ; 116–136 × 10 μ; 84–102 × 8 μ.

The ascospores are oval, or broadly oval, one-septate, thick-walled, ends obtuse, hyaline, becoming yellowish, not constricted at the septum, wall minutely warted, 13–22 × 7–9 μ. Measurements from different gatherings are 17–20 × 8–9 μ, one 14 × 6 μ, another 16 × 5 μ (old spores; asci not present); 14–20 × 7–9 μ, a few 17–18 × 6 μ; 13–16 × 8–9 μ, with some, in the ascus, globose, continuous, thick-walled, 9–10 μ diameter; 13–18 × 7–9 μ, one 16 × 5 μ; 16–22 × 8–9 μ. The specimen on *Chionaspis biclavis* on *Tabernaemontana* has spores 14–17 × 6–7 μ, in asci 84–102 × 8 μ, but in all other respects it does not differ from the other gatherings.

Parkin recorded a *Nectria* on *Asterolecanium miliaris* on Bamboo which he considered different from *Nectria coccidophthora*. The available perithecia on this specimen are immature, but they resemble those of *Nectria coccidophthora*, in being covered with yellow granules. From one old weathered perithecium, however, spores, some of them germinating, were obtained, which measured 21–27 × 9–10 μ. They are oval, somewhat attenuated towards one end, slightly constricted, pale yellow, thick-walled, with the wall minutely warted. Parkin describes them as elliptical and somewhat pointed, 22–27 × 9–10 μ, and the ascus as 115 × 13·5 μ. He also records that the conidia, which are not now present, measured 100–110 × 5·5–7·5 μ. The constriction of the ascospores may be disregarded, as extruded *Nectria* spores frequently swell, so that they become constricted at the septum, but the dimensions of the spores are greater than anything observed in *Nectria coccidophthora*. The specimen, however, is not now in good condition, and, provisionally, I would refer it to *Nectria coccidophthora* on the general characters of the perithecium.

(To be continued in next part.)

Published the 15*th July*, 1921.

The whole of the first part of the British Mycological Society's Transactions (Season 1896–1897) has now been sold.

The other parts may be purchased at the following prices:—

	Vol. I.	
Season 1897-1898	at . .	5/6
1898-1899	at . .	5/6
1899-1900	at . .	7/6
1900-1901	at . .	11/6
	Vol. II.	
1902	at . .	11/6
1903	at . .	11/6
1904	at . .	15/-
1905	at . .	15/-
1906	at . .	15/-
	Vol. III.	
1907	at . .	15/-
1908	at . .	16/-
1909	at . .	16/-
1910	at . .	16/-
1911	at . .	16/-
	Vol. IV.	
1912	at . .	16/-
1913	at . .	16/-
	Vol. V.	
1914	at . .	16/-
1915	at . .	16/-
1916	at . .	16/-
	Vol. VI.	
1917	at . .	16/-
1918	at . .	16/-
1919	Pt III at .	8/-
1919	Pt IV at .	10/6
	Vol. VII.	
1920	Pts I & II at	12/6

All applications respecting past Transactions should be made to the Treasurer.

CONTENTS

PAGE

The Minehead Foray. By J. Ramsbottom, M.A. . . 1

Mycetozoa found during the Minehead Foray. By G. Lister, F.L.S. 10

Mycetozoa at Porlock in October, 1920. By Norman G. Hadden 13

The Lichens of Minehead District. By H. H. Knight, M.A. 16

Presidential Address. By T. Petch, B.A., B.Sc. . . 18

The Sporulation of Gonidia in the Thallus of *Evernia prunastri* Ach. By Robert Paulson, F.L.S. . . 41

Three Fungi Imperfecti. By Jessie S. Bayliss Elliott, D.Sc., and Helena C. Chance, M.Sc. . . . 47

Two New Basidiomycetes. By H. Bourdot . . . 50

New British Hymenomycetes. By A. A. Pearson, F.L.S. 55

New or Rare British Discomycetae. By Carleton Rea, B.C.L., M.A. etc. 58

Upon the Ocellus Function of the Subsporangial Swelling of Pilobolus. By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C. 61

On the Life History and Morphology of *Urocystis Cepulae*. By T. Whitehead, A.R.C.S. 65

The Inheritance of Disease-Resistance in Plants. By F. T. Brooks, M.A. 71

Notes on New or Rare British Fungi. By Malcolm Wilson, D.Sc., F.L.S., F.R.S.E. 79

Notes. Audibility of the spore discharge in *Otidea leporina*. By R. B. Johnstone 86

Californian Bees. By J. Ramsbottom, M.A. . 86

Studies in Entomogenous Fungi. By T. Petch, B.A., B.Sc. 89

CAMBRIDGE: PRINTED BY J. B. PEACE, M.A., AT THE UNIVERSITY PRESS

VOL. VII, PART III. *Published* 13 *December*, 1921

The British Mycological Society

(*Recognosce notum, ignotum inspice*)

TRANSACTIONS 1920

Edited by

CARLETON PEA and J. RAMSBOTTOM

Price to non-members, 12/6

CAMBRIDGE
AT THE UNIVERSITY PRESS
1921

LIST OF OFFICERS AND COUNCIL FOR 1921

Elected September 1920

President

CARLETON REA, B.C.L., M.A., Hon. memb. Brit. Myc. Socy, etc.

Vice-Presidents

Miss GULIELMA LISTER, F.L.S., T. PETCH, B.A., B.Sc.

Treasurer and Foray Secretary

A. A. PEARSON, F.L.S.
59, Southwark Street, London, S.E. 1.

General Secretary

J. RAMSBOTTOM, M.A., F.L.S., O.B.E.
British Museum (Nat. Hist.), Cromwell Road, London, S.W. 7.

Secretary

Miss E. M. WAKEFIELD, F.L.S.
The Herbarium, Royal Botanical Gardens, Kew, Surrey.

Editors

CARLETON REA, B.C.L., M.A.
and
J. RAMSBOTTOM, M.A., F.L.S., O.B.E.

COUNCIL

The OFFICERS, with the following in addition:

W. B. ALLEN, Prof. R. H. BIFFEN, F. T. BROOKS, Prof. A. H. R. BULLER, Miss D. M. CAYLEY, A. D. COTTON, Very Rev. D. PAUL, T. PETCH, Prof. M. C. POTTER, Mrs E. A. REA, Miss A. LORRAIN SMITH, E. W. SWANTON, and H. WAGER.

SUB-COMMITTEE FOR PLANT PATHOLOGY

F. T. BROOKS, M.A. (*Chairman*)
E. J. BUTLER, C.I.E., D.Sc.
A. D. COTTON, F.L.S. (*Secretary*)
T. PETCH, B.A., B.Sc.
G. H. PETHYBRIDGE, B.Sc., Ph.D.
J. RAMSBOTTOM, M.A., F.L.S.

The President and Secretary of the Society *ex Officio*.

STUDIES IN ENTOMOGENOUS FUNGI.

THE NECTRIAE PARASITIC ON SCALE INSECTS.

(continued from p. 132)

LIBRARY
NEW YORK
BOTANICAL
GARDEN

By T. Petch, B.A., B.Sc.

NECTRIA.

Nectria diploa B. and C.

This species was described by Berkeley and Curtis in Jour. Linn. Soc. x (1868), p. 378, as "Caespitosa; peritheciis aurantiacis furfuraceis; sporidiis biseriatis fusiformibus, 2–4 nucleatis (606). On bark. Hab. Car. Inf., No. 4029. Sporidia ·0012–·001 inch long, ·00035 wide." The specimens were from Cuba, and, as explained by Berkeley, in the introduction to Fungi Cubenses, the places cited under "Habitat" are extra-Cuban localities from which he believed he had the same species.

The type in Herb. Kew is marked 606; it is a caespitose *Nectria*, on a scale insect, apparently *Aspidiotus*, and has a *Pseudomicrocera* conidial stage. Specimens distributed in Fungi Cubenses Wrightiani, No. 767, are the same species, as regards the examples in Herb. Kew and Herb. British Museum. Von Höhnel (in Herb. Kew) states that *Nectria diploa* B. and C. is the same as *Nectria lacticolor* B. and C., but that is not the case.

The specimens from South Carolina, No. 4029, are a totally different species. These were subsequently described by Berkeley (Grevillea, IV (1875), p. 46) as *Nectria diploa* B. and C. var. *minuta*, on some *Sphaeria* on alder, Car. Inf., No. 4029, but they have no relationship or resemblance to the Cuban species. The perithecia are minute, conical, about 160 μ high and 120–200 μ diameter, blood red, smooth, translucent, collapsing laterally, with a papillate apex; the asci are sessile, narrow oval, about 70 × 12 μ, and the ascospores oval or subcymbiform, 22–24 × 8–10 μ. According to von Höhnel in Herb. Kew, this is the same as *Nectria guaranitica* Speg. There are specimens in Herb. British Museum, "*Nectria diploa* B. and C., 55, ad corticem *Alni*," marked by Broome "Ravenel, (spore) about 0·0012 inch long," with a drawing of the spore; "*Nectria diploa* B. and C., Cort. Alni, Society Hill, S.C., M.A.C.," with drawing of spore "·001 inch long"; and "*Nectria diploa* B. and C., coll. M. A. Curtis, Distrib. W. G. Farlow"; while Herb. Kew has "4029, on *Alnus*, Car. Inf." All these appear to be the same, but not *Nectria diploa*. This species is parasitic on lichens or *Pyrenomycetae*.

Seaver (Mycologia, I, p. 190) places *Nectria diploa* in *Creo-*

nectria, and states that it is only known from the type locality, South Carolina. He cites Ravenel, Fungi Car. Exsicc., No. 55. It is evident that this refers not to *Nectria diploa* but to the Carolina species which Berkeley confused with it.

Nectria diploa has been collected in Ceylon on two occasions—on *Fiorinia rubrolineata* on *Murraya exotica*, Peradeniya, and on *Lepidosaphes* sp. on an undetermined plant, Kandy. I have also a specimen of *Pseudomicrocera* on *Fiorinia fioriniae* on *Camellia* from Mauritius, which bears immature perithecia, apparently of this species.

The perithecia are situated on the old conidial stroma (Plate III, fig. 13), which forms a narrow, compact, pink border round the scale, with a narrow, white, byssoid margin, or sometimes a broader, scarious margin. In the available specimens, effete *Pseudomicrocera* sporodochia, either horizontal or oblique, are present. The perithecia are scattered, or clustered in groups up to six; they are globose or slightly ovoid, up to 0·4 mm. diameter, bright red, with a darker red ostiolum. In old herbarium specimens, the perithecia become orange-red or orange-yellow. They bear a few large warts, up to 0·1 mm. high, which are sometimes confluent and form a continuous crust except round the ostiolum. These warts are composed of oval, or globose, rather thick-walled cells, 7–13 × 7–12 μ. The asci are clavate, sessile, either four-spored, 64–68 × 12 μ, or eight-spored, 96–116 × 10–14 μ, both being found in the same specimen. The ascospores (Plate V, fig. 22) are pale yellow, at first pluriguttulate, then one-septate, not constricted, ends obtuse, elliptic, narrow-oval, or subcymbiform, 16–32 × 6–9 μ. Berkeley's measurement of the ascospore was 25–30 × 9 μ.

This species was described by Spegazzini as *Nectria coccorum* in Fungi Guaranitici, Pugillus I, No. 234, and as *Nectria coccogena* in Fungi Puiggariani, No. 289. Prof. Spegazzini has kindly submitted for examination his specimens of these and other coccid Nectriae.

Nectria coccorum is represented in Herb. Spegazzini by the type, No. 3867, on fallen leaves of some *Laurineae*, Peribebuy, Brazil, July 1883, and No. 4046, Paraguay, November 1883. Both the specimens show a *Pseudomicrocera* conidial stage, with typical conidia, 60–78 × 4 μ. The surface of the stroma in the type is rather more tomentose than in the Eastern forms, or in other American specimens but that may be due to the fact that the specimens occurred on fallen leaves. The perithecia are superficial on the stroma, either isolated or two or three together: they are about 0·2 mm. diameter, covered with warts composed of large cells, or pruinose, with a continuous layer of the same cells.

Unfortunately, all the specimens of *Nectria coccorum* appear to be too immature to show recognisable ascospores. Spegazzini described the ascospore as cylindrico-fusoid or elongated elliptical, "utrinque obtuse acutatis," 22–25 × 5 μ, one-septate, not or slightly constricted, hyaline, and the herbarium specimens bear figures which show them as fusoid, constricted or not at the septum, with obtuse, acuminate ends. I was able to find one spore of this character (16 × 5 μ), but it was pale brown. It would seem probable that these spores are intrusive, and belong to some Sphaeriaceous fungus, not to the *Nectria*.

The type of *Nectria coccogena* is No. 2338 in Herb. Spegazzini, on leaves of a *Eugenia*, near Apiahy, Brazil. Its *Pseudomicrocera* conidia measure 82–96 × 4–5 μ. The perithecia are scattered or clustered, up to 0·4 mm. diameter, covered with large, irregular warts. The ascospores are elliptic to narrow-oval, sometimes subcymbiform, ends obtuse, one-septate, not constricted, thick-walled, yellowish, 16–24 × 6–9 μ (Plate V, fig. 18). In the original description of *Nectria coccogena*, the perithecia were said to be at first covered with a cottony hyaline pruina; it is possible that this may refer to the tip of the sporodochium, its base having been mistaken for a developing perithecium. The difference in size of the perithecia of *Nectria coccorum* and *Nectria coccogena*, may be partly due to the fact that the former is immature, but it is chiefly owing to the greater development of the warts in the latter species. It is not possible to separate these two on the available material.

The variation in the size and shape of the ascospores is remarkable. In the Ceylon examples, most of the ascospores are narrow-oval or subcymbiform, 22–32 × 7–8 μ, only a few being elliptic and 16 × 7–8 μ. In *Nectria coccogena*, type, the variation of the ascospore was from 16 × 8 μ to 24 × 7 μ in the one perithecium; many asci contained only elliptic spores, and the longer spores were slightly broader (in proportion) and less decidedly cymbiform than in the Ceylon form.

"*Nectria coccorum* Speg., Balansa, Pl. de Paraguay, 4046, Nov. 1883" in Herb. Kew, is *Nectria diploa*. This is apparently the same collection as "*Nectria coccorum* Speg., No. 4046, Paraguay, Nov. 1883" is Herb. Spegazzini. It is also represented in Herb. Kew by "3547, Roumeguère, Fungi Gallici Exsiccati, *Microcera coccophila* Desm., on coccus on leaves of *Myrtaceae*, Paraguay, Sept. 1883 (J. Balansa 4046)," which is *Pseudomicrocera Henningsii* with well-developed *Nectria diploa*. "Roumeguère, Fungi Selecti Exsiccati, No. 5229, on a coccus on leaves of *Pilocarpus pinnatus*, Paraguay, Coll. Balansa," issued as *Nectria coccorum* Speg., is also *Nectria diploa*, and the same is true of "*Nectria oidioides* Speg., *myrticola* Rehm on

Eugenia sp. Blumenau, Nov. 1888, Ule, Herb. Brasiliense, No. 1288"; for both these, the examples in Herb. Kew have been examined.

In Herb. British Museum, there are specimens of *Pseudomicrocera Henningsii* from Florida communicated by E. W. Berger under the name *Sphaerostilbe coccophila*. One collection, on Florida red scale of citrus (*Chrysomphalus aonidium*), contains eight leaves, six of which bear *Pseudomicrocera Henningsii* and two, *Microcera aurantiicola*. Another, on purple scale of citrus (*Lepidosaphes beckii*), consisting of six specimens, is *Pseudomicrocera Henningsii*, except as regards one specimen which is *Microcera aurantiicola*.

Other specimens of *Pseudomicrocera Henningsii* have been referred to under *Pseudomicrocera*.

Nectria coccophila Nomura.

This species, described by Nomura in 1901, was found by him on *Aspidiotus perniciosus* on *Pyrus sinensis*, and *Diaspis pentagona* on *Morus alba*, in Honsui, Japan. Miyabe and Sawada were apparently unacquainted with it, but cite Nomura's description, as follows.

Sporodochia irregularly pulvinate, not stilboid, orange-red, on a reddish stroma, sometimes confluent. Conidia falcate, of the *Fusarium* type, three- to five-septate, reaching 100 μ in length. Perithecia flask-shaped, bright red, appearing on the outer surface of the scale, three to four in a group, 260–340 μ high, 240–320 μ broad. Asci fusiform, obtusely pointed at the apex, 90–110 × 8–10 μ, eight-spored, spores uniseriate, more or less oblique. Spores light brown, one-septate, slightly constricted at the septum, 15–20 × 5–6 μ. Stroma scarlet, sclerotioid in texture.

Nomura compared his species with Rolf's figures of *Sphaerostilbe coccophila*, and came to the conclusion that the Japanese and Florida species were the same, but that neither was *Sphaerostilbe coccophila* Tul. This, however, does not afford much assistance in deciding what his species was, for Florida writers have confused *Microcera* and *Pseudomicrocera*, and some of Rolf's figures appear to belong to the latter. Nomura stated that the sporodochia of his species were not stilboid, but irregular protuberances of the type of *Tubercularia*; this again does not help, because in all these species the base of the conidial stage may be reduced almost to vanishing point.

Miyabe and Sawada would appear to incline to the view that *Nectria coccophila* Nomura is identical with *Sphaerostilbe coccidophthora* Zimm. The dimensions of the ascospores are too large for *Sphaerostilbe flammea* or *Sphaerostilbe aurantiicola*, and would agree better with that determination. But the statement

that the sporodochia are seated on a reddish stroma, and that the stroma is scarlet and sclerotioid, points rather to *Nectria diploa*. The description of the conidia as falcate, and three- to five-septate also indicates *Nectria diploa*, and had the breadth of the conidia been given, the description would have been decisive. *Nectria diploa* has coloured ascospores, though they are yellow rather than brown, and the dimensions given are near those of its smaller ascospores. Consequently, if there is no other way of deciding what this species was except by guessing from the description, I should conclude that it was *Nectria diploa*. Judging from the available collections, the perithecia of *Nectria diploa* are much rarer than those of the various species of *Sphaerostilbe* found on scale insects.

A conidial specimen kindly forwarded to me under this name by Prof. Hara, collected on *Aspidiotus* on *Pyrus*, Shizuoka, June 20, 1919, is *Sphaerostilbe aurantiicola* (B. and Br.). The synnemata are pulvinate, but a few are very shortly stalked. The conidia are almost straight with falcate tips, and multiseptate.

Nectria variabilis Hara.

This species was found on a Coccid on *Sasa paniculata* in the Gifu Prefecture, Japan. I have not been able to examine a specimen.

According to the original description, the sporodochia are erumpent (*sic*), irregular, orange-red or rose-coloured, mostly one to two, rarely three, on a scale, 0·5–1 mm. diameter. The conidiophores are filiform, septate, branched at the base, 2·5–3 μ diameter. The conidia are fusariiform, three- to five-septate, 60–70 × 5–6 μ; and filiform paraphyses, hyaline, septate, 2–2·5 μ diameter are present. The perithecia are produced at the base of the sporodochia or on a stroma, and are globose or elliptic, with a papillate ostiolum, solitary or clustered, smooth, carinous (*sic*) membranaceous, orange-red, 270–300 μ diameter. The asci are cylindrico-clavate, apex rounded, stipitate, eight-spored, 130–150 × 11–13 μ, accompanied by filiform paraphyses, 1–1·5 μ thick. The ascospores are uniseriate, fusiform or elliptical, one-septate, slightly or not constricted, 16–22 × 6–9 μ, hyaline or yellow.

Hara's figures show conidia slightly but regularly curved, and ascospores narrow-oval to subcymbiform. His figure of the whole fungus is unrecognisable. From his figures and description of the conidia, they belong to *Pseudomicrocera Henningsii*, though the breadth is rather too large. The ascospores described and figured are those of *Nectria diploa*, but the description of the perithecium does not fit. The balance of evidence is in favour of the supposition that this species also is *Nectria diploa* B. and C.

Nectria Tuberculariae Petch.

A *Nectria* which does not appear to have been previously described has been found on *Lepidosaphes* sp., on orange, in Ceylon. It occurred in company with *Nectria aurantiicola* B. and Br., *Ophionectria coccicola* E. and E., and *Septobasidium rameale* (Berk.), on a tree which had been imported from West Australia five years before.

The perithecia are situated on the scale, or on a thin, white, byssoid stroma, which envelops the scale and spreads out over the leaf. The entire stroma can readily be detached from the leaf, and then presents a smooth, white, under surface, as in *Ophionectria coccicola*. The margin of the stroma is fimbriate.

The perithecia are scattered or clustered, up to 0·2 mm. diameter, globose, with a very minute, conical ostiolum, pale flesh-coloured, with a white pruina (Plate IV, fig. 8). The wall of the perithecium is obscurely parenchymatous, of small cells, and villous with short, spreading, hyaline hairs. The asci are cylindric, eight-spored, spores obliquely uniseriate, 50–62 × 6 μ, furnished with paraphyses which soon disappear. The ascospores (Plate V, fig. 9) are oval, or oblong oval, one-septate, not constricted, hyaline, minutely warted, 6–9 × 4–5 μ. A number of globose spores, about 4 μ diameter, are present: these appear to be aborted ascospores, not part-spores.

With these, on similar stromata, there occurs a *Tuberculariа* conidial form. The sporodochia are variable. In the larger forms (Plate IV, figs. 5, 6) they are flattened pulvinate, compact, oval, or circular, up to 1 mm. long and 0·6 mm. broad, situated at the edge of the scale, and often confluent so as to hide it completely. In other cases the stroma bears small scattered patches of conidia which are barely elevated. The sporodochia are at first pink, with a whitish margin, and minutely pruinose, but, when covered with the spores, they are uniformly pink, or inclining to orange red when moist, waxy, without any evident margin. The byssoid stroma of the conidial stage usually spreads further over the leaf than that of the perithecial stage, and, at its outer edge, one often finds somewhat loose, pinkish tufts of hyphae which are evidently the early stages of other sporodochia. This running habit is especially well-marked, where the *Tuberculariа* is in company with a *Septobasidium* which has developed its bristles. The hyphae of the *Tuberculariа* then ascend the bristles, and form minute pink sporodochia at the apices. The bases of the larger stromata are plectenchymatous. The conidiophores are branched at about one-third of their height, and the branches are clustered, about 30 μ high, 2 μ diameter below, tapering to the apex. The spores are cylindric

with rounded ends, up to 6 × 2·5 μ, or oval, 3–5 × 2–3 μ, or globose 2·5 μ diameter, hyaline, continuous.

This conidial form appears to be identical with *Tuberculariа coccicola* Stevenson, which was found on *Lepidosaphes beckii* and *Hemichionaspis minor*, on *Citrus*, in Porto Rico, in company with *Ophionectria coccicola*, and species identified as *Sphaerostilbe coccophila* and *Microcera Fujikuroi*.

Tuberculariа coccicola was described as having scattered, or clustered sporodochia, superficial, pulvinate, compact, from 0·5–4 mm., averaging 1–2 mm., sometimes uniting irregularly, grenadine pink to safrano pink (Ridgway), fading to dull white with age; margin regular, not setose; conidiophores hyaline, septate, 15–36 μ long, 1·5 μ diameter; conidia forming dense masses on the sporodochia, pink in mass, hyaline by transmitted light, ovoid to cylindric, not guttulate, 2–4 × 1·5–2 μ.

Mr Stevenson has kindly forwarded me a specimen of *Tuberculariа coccicola*, on *Lepidosaphes beckii* on *Citrus decumana*, Espinosa, Porto Rico, March 1917 (No. 6366, Insular Experiment Station, Porto Rico). The individual sporodochia are usually small, but they may be confluent in large masses; they are flattened-pulvinate, circular or oval, usually somewhat pruinose in the dry specimens, but sometimes waxy. The conidiophore is the same as in the Ceylon form, and there is the same mixture of narrow-oval and globose spores. In general, the sporodochia lack the byssoid stroma which is so prominent in the Ceylon form. A slight development of the stroma is however present in some cases, and it would appear probable that the difference between the Ceylon and Porto Rican forms in this respect may be a climatic effect. The two forms are too close to be separated as conidial stages of different fungi, though, when the difficulty of differentiating between other conidial forms of fungi found on scale insects is borne in mind, it must be admitted that the discovery of the *Nectria* of the Porto Rican fungus might demonstrate that they are not identical.

A specimen from South India differs in some respects from the type. It was collected on the Western slope of the Nilgiris, October 1910, on the stems of a small bamboo (indet.), associated with an *Asterolecanium*. Only two sporodochia are present. The sporodochia are superficial, circular, up to 2·5 mm. diameter, flat, thin, with a definite edge; there is no spreading mycelium. The base of the sporodochium is somewhat lax, composed of loosely interwoven, slender, hyaline hyphae up to 2 μ diameter; the upper portion consists of a definite continuous layer of erect conidiophores. The conidiophores are short, about 12 μ high, simple, with conidia, narrow-oval, hyaline, 2–4 × 1·5–2 μ. The colour of the stroma is now white.

One of the sporodochia described above bears a few perithecia partly embedded in it, and crowded together at the edge. The other bears similar perithecia, somewhat crowded, situated all over the sporodochium, and embedded in it. The available specimens have been pressed; in them, the upper part of the perithecium does not project above the sporodochium, but it would appear probable that in a natural condition the perithecia projected for about one-third their height. The perithecia agree exactly with those of *Nectria Tuberculariae*: the ascospores are narrower, 6–8 × 2·5–3 μ, but they are immature.

This specimen differs from the type in the absence of the byssoid stroma which is so noticeable in the former collection, and in the development of the perithecia in the old sporodochia. But it is too close to be separated on the present material.

Nectria barbata n.sp.

An undescribed species of *Nectria* was found on *Lepidosaphes* sp. on *Citrus aurantium*, Glenugie, Ceylon, March 1919.

The perithecia are scattered over the scale, without any stroma, sometimes with a slight basal weft of hyphae. They are conoid or subglobose, about 0·2 mm. diameter, and 0·3 mm. high, collapsing, minutely rugose, yellow-brown or dark amber, subtranslucent (Plate III, fig. 14). The ostiolum is broadly papillate or obtusely conical, and is surrounded, at a short distance below, by a varying number of erect, white, rigid hairs, arranged more or less in a ring. These hairs (Plate V, fig. 4) are up to 50 μ high, 4 μ diameter below, equal, or slightly inflated at the obtuse tip. The perithecial wall consists of an outer, brown, collapsed or amorphous layer which splits into irregular patches, and an inner, hyaline, membranous wall composed of moderately large cells. The asci are cylindrico-clavate, eight-spored, 66 × 6–8 μ, with spores uniseriate, or obliquely uniseriate, or sometimes transverse (Plate V, fig. 5). The spores (Plate V, fig. 6) are hyaline, oblong-oval, ends broadly rounded, one-septate, strongly constricted, 6–8 × 3–5 μ.

I name this species *Nectria barbata*. Its conidial stage has not been observed.

LISEA.

Lisea Parlatoriae Zimm.

This species was described from specimens on *Parlatoria zizyphi* Luc., on *Citrus* leaves, found at Buitenzorg, Java.

The perithecia are crowded, superficial, globose with a papillate ostiolum, 0·2–0·25 mm. high, and 0·15–0·18 mm. diameter, appearing black. By transmitted light, the colour of the perithecial wall is dark violet to black, becoming red-violet on

heating with chloral hydrate. The asci are cylindric and eight-spored, without paraphyses. The ascospores are elliptic, obtuse, one-septate, not constricted, hyaline or slightly brownish, 9–12 × 4·5 μ.

The above details are taken from Zimmermann's description. No specimens of *Lisea* on scale insects have come under my notice.

CALONECTRIA.

Calonectria coccidophaga Petch.

This species, specimens of which were kindly submitted to me by Mr C. C. Brittlebank, occurred on *Planchoma acaciae*, on *Acacia* sp. at Warburton, Victoria, April 30, 1917 (Coll. J. Farrell).

The perithecia are clustered, in pulvinate groups up to 2 mm. diameter, on a fairly well-developed parenchymatous stroma (Plate IV, figs. 3, 4). The cluster appears black, but on detaching the perithecia, they are found to be black in the upper part, but pinkish-yellow below, and the stroma is yellowish. From the colour of the perithecium when immersed in water, it is probably very dark red when fresh. The perithecia are globose, about 0·4 mm. diameter, pruinose, naked at the apex. In some specimens, the apex is papillate, but in other examples it is flat and discoid with a punctiform ostiolum. The wall in section, and internally, is rose-red (Plate IV, fig. 3); it is very thick, and when mounted the outer layer is vinous or purplish-red while the inner layers are yellowish-white. It has a somewhat horny appearance in the dry specimens. The asci are clavate, eight-spored, with spores biseriate above, uniseriate below, 120–140 × 14–16 μ, and are accompanied by stout paraphyses, branched above, with granular contents. The spores (Plate V, fig. 7) are oblong-oval or subcymbiform, straight or curved, with obtuse ends, three-septate, sometimes constricted at the septa, especially at the median septum, 22–34 × 8–9 μ. Occasionally a spore is four-septate, one-half being two-septate. Immature spores in the ascus, though with developed septa, may be fusoid and only 5 μ broad.

With the foregoing, there occurred a conidial stage which is undoubtedly *Microcera tasmaniensis* McAlp. Mr Brittlebank has kindly submitted to me the type of *Microcera tasmaniensis* McAlp., on a scale on *Eucalyptus*, Tasmania (A. M. Lea), Aug. 8, 1901, and that of *Microcera Mytilaspis* McAlp., on *Mytilaspis* sp., on *Hymenanthera dentata*, Ivanhoe, Victoria, Sept. 14, 1903. On comparison, it appears that these two species are identical, the first being a younger development of the second. The type of *Microcera Mytilaspis*, though at first sight different from

Microcera tasmaniensis, contains examples which exactly match the latter and their structure leaves no doubt as to their identity. It is not *Microcera* of Desmazières.

The conidial fructifications arise either from a narrow, rather loose weft of hyphae, round or at one side of the scale, or from the hyphae which permeate the scale, without any external stroma. The smaller examples (Plate IV, fig. 2), which constitute *Microcera tasmaniensis*, are clustered, sessile, pulvinate, or subglobose, up to 0·3 mm. diameter, or sometimes discoid. In the dry specimens, they are white and longitudinally tomentose externally, and yellowish and subtranslucent in the centre, but when fresh, they are salmon pink (*fide* McAlpine). The more recent specimens on *Planchoma* retain the pink colour in the centre. The outer layers are composed of parallel hyphae, 4 μ diameter, rather closely septate, running uniformly from base to apex: they form a wall, several hyphae thick, which sometimes projects above the central disc. The central disc consists of close-packed conidiophores, bearing three-septate, fusarioid spores. The internal tissue of the sporodochium, beneath the disc, is parenchymatous. The conidia (Plate V, fig. 13) are slightly falcate, or almost straight, ends obtuse, 44–58 × 5–6 μ. The majority are three-septate, but four- and five-septate examples have been observed.

In the type of *Microcera Mytilaspis* some of the sporodochia answer to the above description, but the majority are larger and more fully developed (Plate IV, fig. 1). The latter are distinctly discoid, usually oval in plan, up to 0·8 mm. long and 0·6 mm. broad, either sessile on the marginal stroma, or shortly stalked. The upper surface is concave, and the outer wall of parallel hyphae is continued well above the disc and strongly incurved. The specimens have exactly the appearance of a *Peziza*. In the shallower sessile specimens, the tissue underlying the disc is small-celled parenchymatous, but in the stalked forms, the cells in the centre are arranged more or less in longitudinal parallel rows. In the latter case, however, they are 4–6 μ broad, septate at fairly close intervals (10–20 μ), with the segments somewhat inflated; the stalk is not composed of long, slender, uniform hyphae as in *Microcera*. The conidia in *Microcera Mytilaspis* are of the same type as in *Microcera tasmaniensis*, and measure 44–54 × 5–6 μ.

In the sporodochia found with the *Calonectria*, the conidia are 30–36 × 4–5 μ, three-septate, occasionally four-septate, almost straight, or curved, or straight with falcate tips, ends obtuse.

A few conidiophores at the margin of the disc may be up to 100 μ long, unbranched, and bear conidia laterally and terminally. The conidiophores in the disc are usually short, re-

peatedly branched, with short, slightly inflated segments, and conidia terminal. The type of branching is fusarioid.

This type of fructification resembles *Pseudomicrocera* in form and in its parenchymatous base, though its general appearance is different owing to the more obvious development of the disc. It differs from *Pseudomicrocera*, however, in the type of conidiophore, and in the continuous wall of parallel hyphae which forms the outer layer of the whole sporodochium. It is a *Fusarium*, with the general shape of a *Peziza*. I propose to call this *Disco-fusarium*.

Disco-fusarium gen. nov. *Tuberculariaceae*. Sporodochium discoid, sessile or shortly stalked, the external layers composed of parallel hyphae, continuous from the base, extending above the disc and forming an incurved margin; disc composed of branched conidiophores; conidia hyaline, fusarioid, multiseptate.

Disco-fusarium tasmaniense (McAlp.); *Microcera tasmaniensis* McAlp., Agric. Jour. Victoria, II (1904), pp. 646–648; *Microcera Mytilaspis* McAlp., *loc. cit.*

There are specimens of *Disco-fusarium tasmaniense* in Herb. Kew, in the cover of *Microcera coccophila*, labelled "On *Acacia*, Grampians, V.," which presumably were from Victoria.

PODONECTRIA.

A *Nectria* with long, septate spores, parasitic on scale insects on orange trees in Florida, was described by Ellis and Everhart in 1886 as *Nectria coccicola*. They stated that it belonged to the subgenus *Ophionectria*, and subsequent references to it have, until recently, employed the latter name.

A similar fungus was found by Zimmermann in Java on *Parlatoria zizyphi* on *Citrus*, and was regarded by him as the same species. He also described the conidial form, which was not recorded by Ellis and Everhart.

The perithecia (Plate IV, fig. 9) are pale to dark brown, thick-walled, with thick-walled asci, which are furnished with paraphyses, and contain long, clavate, septate spores, 100–120 μ long. The conidial stage (Plate IV, fig. 9) is strikingly different from that of other species of *Nectria*; it consists of a short parenchymatous column, which bears at the apex a white, conical head of conidia. The conidia (Plate V, figs. 1–3) are long and septate; they are borne, usually in threes, at the apex of the conidiophores, and they remain united together at the base when detached from the conidiophores. The number in a detached cluster varies, however, from three to five.

In 1913, Miyabe and Sawada recorded *Ophionectria coccicola* from Formosa, where it occurred on *Parlatoria zizyphi* (Lucas) Sign., *Aspidiotus ficus* Comst., *Mytilaspis gloverii* (Pack.) Comst.,

and *Mytilaspis citricola* (Pack.) Comst., on *Citrus nobilis* Lour. They also described a new species, *Ophionectria tetraspora* Miyabe and Sawada, which differed from *Ophionectria coccicola* in having conidia with acute or obtuse tips, usually in fours, and ascospores, 50–64 × 6·5–7·5 μ.

Meanwhile, Seaver, in 1909, had transferred Ellis and Everhart's species to a new genus, *Scoleconectria*. The latter genus contains species provided with a stroma, and having spores from three- to many-septate. It thus includes species which were formerly referred to *Ophionectria* and *Calonectria*, the common distinguishing character being the presence of a stroma. Seaver describes the stroma of *Ophionectria coccicola* as rounded, more or less prominent, whitish. The fungus forms a thin, white, byssoid layer, which spreads out from the scale over the leaf, or stem, in a more or less circular patch, if the scales are far enough apart to permit it to develop without interference. This layer becomes brownish, and the hyphae fuse together, in part, into a membranous sheet, which separates readily from the leaf. The perithecia and sporodochia are produced on this sheet, often at some distance from the scale insect. Where the scale insects are crowded, the thin sheet of hyphae grows over them and binds them together.

Of course, the hyphae of the fungus also penetrate the body of the scale insect, and the central part of the stroma is slightly elevated by the presence of the latter within it; but elsewhere the stroma is thin, flat, and membranous.

The practicability of separating species of *Nectria* into genera, according to the presence or absence of a stroma, has been questioned by other mycologists. But if that basis of division is followed, it would seem preferable to restrict the term stroma, in that application, to the parenchymatous forms. If the term is used to include any basal layer of hyphae, the classification becomes unworkable. *Ophionectria coccicola* does not possess a stroma in the sense that *Nectria cinnabarina* does.

Seaver's separation of *Scoleconectria* from *Ophionectria*, on account of the presence of a stroma in the former, cannot stand if such a basal layer as that of *Ophionectria coccicola* constitutes a stroma. For, as previously stated (Ann. Perad., v, p. 285), in the type species of the genus *Ophionectria*, *Ophionectria trichospora* (B. and Br.) Sacc., the perithecia are seated on a thin, byssoid layer, which is just as good a stroma as that of *Ophionectria coccicola*. Therefore, the original genus *Ophionectria* is stromatic, in the sense in which the writer understands Seaver to employ that term, and the separation of *Scoleconectria* as a stromatic *Ophionectria* is based on a misunderstanding of the nature of the type species of the genus *Ophionectria*.

Von Höhnel has raised objections to Seaver's genus *Scoleconectria* on other grounds. In 1902, Hennings instituted the genus *Tetracrium* for a conidial fungus found on scale insects on the leaves of orange in Brazil. Von Höhnel has examined the type specimen, and finds that this is identical in structure with the conidial stage of *Ophionectria coccicola* (Fragmente zur Mykologie, XIII, p. 27). Hennings' species was named *Tetracrium Aurantii*, and von Höhnel names the conidial form of *Ophionectria coccicola*, *Tetracrium coccicola*. But von Höhnel found perithecia of the same character as *Ophionectria coccicola* in the type specimen of *Tetracrium Aurantii*, and these he regards as belonging to the genus *Puttemansia* Henn. (1902).

According to von Höhnel, *Scoleconectria* is equivalent to *Puttemansia*, both being *Ophionectria* provided with a stroma. This again overlooks the fact that the type species of the genus *Ophionectria* has a stroma.

Puttemansia was described by Hennings as a genus of *Discomycetae*, the type species being *Puttemansia lanosa*. The type specimen has been re-examined by von Höhnel, who stated in his first communication on the subject (Fragmente zur Mykologie, XII, p. 23) that it was a stromatic *Calonectria*, and equivalent to *Scoleconectria* Seaver, the latter genus including species with long, multiseptate spores, and others with elliptic, three-septate spores.

According to von Höhnel (*loc. cit*), *Puttemansia lanosa* builds a parenchymatous stroma within the leaf, which bursts through the epidermis, and forms a superficial, white, external stroma, on which the perithecia are produced. The perithecia are oval, or almost pyriform, 200–280 μ high, 350–420 μ broad, generally immersed in the stroma to one-third, or one-half, their height, and often fused together laterally. The superficial stroma is parenchymatous. The perithecial wall is 40–60 μ thick, rough with projecting groups of cells, and clothed with a woolly covering of thick-walled, septate, obtuse hairs, 300–500 μ long and 5–6·5 μ diameter.

Hennings stated that the stromata were "villo albo omnino tectis," and described the hairs of the perithecial wall as rigid, simple, hyaline, septate, obtuse at the apex, 200–400 × 5–6 μ. The asci were clavate, apex rounded and obtuse, thick-walled, 120–140 × 18–20 μ, furnished with filiform, branched, paraphyses. The spores were oblongo-fusoid, three-septate, 40–50 × 7–8 μ, with a curved basal appendage, 15–20 × 3 μ.

Von Höhnel states that there may be an appendage at one or both ends, but that these appendages are hollow continuations of the end cells, not solid ciliae as in *Paranectria*.

The perithecia found by von Höhnel on the type specimen

of *Tetracrium Aurantii* were named by him *Puttemansia Aurantii* (Fragmente, XIII, p. 28). His description will be quoted later. There can be no doubt that this species is co-generic with *Ophionectria coccicola*, but from the available data it would seem very doubtful whether it is co-generic with *Puttemansia lanosa*. The shape of the spore in the type species of *Puttemansia* is quite different from that in *Ophionectria coccicola*.

The species of *Ophionectria* which are parasitic on scale insects form a natural group, agreeing with one another in having thick-walled asci, long, multiseptate ascospores, and a *Tetracrium* conidial stage. I therefore propose for them a new genus *Podonectria*, the type species being *Podonectria coccicola* (E. and E.).

PODONECTRIA GEN. NOV.

Perithecia seated on a byssoid stroma, nectriaceous; asci thick-walled, spores biseriate; ascospores elongated fusiform, multiseptate, hyaline; conidial stage, *Tetracrium*.

Three species of this genus are known, viz., *Podonectria coccophila* (E. and E.), *Podonectria Aurantii* (von Höhnel), and *Podonectria echinata* n.sp.

Podonectria coccicola (E. and E.) Petch.

I have examined the following collections of this species:—Florida (on citrus, H. S. Fawcett, in Herb. Peradeniya; on orange, Miss Southworth, January, 1910, in Herb. Kew; on purple scale of citrus, E. W. Berger, in Herb. B.M.), Dominica (F. W. South, in Herb. Peradeniya; on *Lepidosaphes beckii* on lime, F. W. South in Herb. Kew), Zululand (J. Parkin in Herb. Peradeniya), Formosa (on *Parlatoria zizyphi* Lucas and *Lepidosaphes gloverii* Pack., on *Citrus nobilis*, Taihoku, April 25, 1911, in Herb. Sapporo), Ceylon (on *Lepidosaphes* sp., on orange, in Herb. Peradeniya).

The stroma fills, or lines, the scale, and spreads out over the host plant in a thin, brownish, byssoid patch. The hyphae are agglutinated, and the margin of the patch tends to become membranous, or scarious. The stroma can easily be detached from the host plant, and then shows a smooth, white undersurface. When the scale insects are scattered, a distinct, circular stroma surrounds, or is situated at the side of, each, but where they are crowded together, the hyphae of the fungus bind the scales together, and the byssoid margin may not be developed. In the former case, the sporodochia and perithecia are scattered over the stroma (Plate IV, fig. 9); in the latter, they are usually densely clustered at the margins of the scale insects.

The sporodochium consists of a cylindrical column, surmounted by a white, usually subconical head. The column is at

first white, but becomes reddish brown; it may be up to 0·6 mm. high, and 0·4 mm. diameter, or so short that the head appears almost sessile on the scale. In the larger examples, the column is often abruptly enlarged into a disc at the apex. The external layers of the column are parenchymatous, the inner plectenchymatous. Towards the apex, the inner hyphae are moniliform, with short, inflated segments, and the conidia are borne, on very short pedicels, on the apical segment. The number of conidia on each conidiophore varies from two to five. When mature, the apical segment, with its attached conidia, separates from the conidiophore, and thus the conidia (Plate V, figs. 1–3) are liberated in clusters of two to five, united by a small, oval, or lozenge-shaped, cell at the base. The head of conidia may be up to 0·3 mm. high.

The individual conidia are hyaline, elongated, multiseptate, cylindric, usually with a long, aseptate, acuminate tip, but sometimes obtuse and rounded at the apex.

In a specimen from Florida, the conidia are 68–180 × 7 μ, mostly 160–180 μ, usually in threes, but sometimes in pairs. Seaver gives the measurement as 100–150 × 7–7·5 μ, and the number in a cluster as three to five. They have long attenuated tips.

In a specimen from Dominica, the conidia are usually in groups of three, and measure 130–250 × 7–8 μ, but sometimes one, sometimes two, spores of the triad are only 50–60 μ long. All have long attenuated tips.

In a specimen from Zululand (on ? *Citrus*, Eshowe, Nov. 1905) the conidia are chiefly in pairs, with a few triads, but, in the latter, one conidium is usually very short. They measure, in general, 100–170 × 8–9 μ, with a few, 52–82 μ long.

In a Ceylon specimen, the conidia are usually in fours, sometimes in threes, and a few in groups of five. They vary in length from 96 to 256 μ, with a few only 50–66 μ. The tips are usually long and acuminate, but some are obtuse and rounded at the apex.

The perithecia (Plate IV, fig. 9) are ovoid, or subglobose, somewhat flattened above, up to 0·5 mm. high, and 0·4 mm. diameter. Perithecia which have developed on the stroma distant from the scale may be distinctly turbinate; this is well-marked in a specimen from Dominica. They are white, but compact, at first, becoming brown or yellowish-brown, and finally dark brown, often blackish at the apex. The wall is minutely rugose. Ellis and Everhart state that the wall bears a few, scattered, white, rudimentary hairs, and Seaver describes it as "at first clothed with a few hyaline hairs," but the only "hairs" I have been able to find are loose clusters of conidia

which have fallen on the perithecia. The wall is parenchymatous, and very thick. The ostiolum is obscure; in some cases, a minute, conical ostiolum, on a very small, flat disc can be detected, but in general this is sunken and the apex of the perithecium appears merely impressed. When mature, the apex is rather widely perforate.

The asci are clavate, tapering below into a short pedicel, with a well-defined foot. They are very thick-walled (up to 8 μ), and the lumen is continued as a short, cylindrical hollow into the thickened apex. Paraphyses are numerous, linear, branched, and slightly shorter than the asci. The asci are eight-spored, with the spores usually biseriate.

Ellis and Everhart gave the dimensions of the asci as 150–190 × 20 μ, and Seaver gives 150–200 × 20 μ. My measurements are, from Florida specimens, up to 270 × 20 μ; from Dominica, 200–240 × 20–22 μ; from Zululand, up to 275 μ; from Ceylon, 250–290 × 24–28 μ. Miyabe and Sawada note that their Formosan specimens apparently differed from North American specimens in the length of the ascus, which was 189–280 μ; but Ellis and Everhart's measurement would appear to be too small.

I have not been able to observe the dehiscence of the asci. In perithecia which contain free ascospores, the asci from which they were liberated seem to have disappeared. In some gatherings, it has been noted that when the spores are mature, the lateral walls of the ascus become thin, but the apex remains thickened. In some instances, when the preparation had been subjected to pressure in an attempt to set free the spores, one issued, for the greater part of its length, through the foot; this occurred in both Ceylon and Florida specimens.

The spores (Plate V, fig. 15) are clavate, rounded above, and tapering to an obtuse point below. The sides are often not straight, but incurved somewhat irregularly about the middle. They are hyaline, multiseptate, sometimes slightly constricted at the septa. Ellis and Everhart gave the dimensions as 110–140 × 6–7 μ; Seaver, as 100–120 × 6–7 μ. My Florida specimens show spores 106–144 × 7–9 μ: Dominica, immature, but up to 100 μ: Zululand, 80–128 × 7 μ, with one ascus, abnormally constricted, in which the longest spore measured 90 μ and the shortest 52 μ: Ceylon, 95–150 × 7 μ (in the ascus), 130–176 × 8 μ (extruded spores), with one abnormal spore, almost as long as the ascus, 225 μ. Rolfs and Fawcett do not give spore measurements, but a rough estimate from their figures would appear to make them 65–80 μ long.

All the collections enumerated appear to be the same species. One point has, however, been observed in a Ceylon gathering,

which, if constant, might have occasioned some doubt. In the Florida, Dominica, and Zululand specimens, at the time when the spores are apparently fully mature, they are clearly visible, with distinctly evident septa, embedded in a small quantity of plasma in the ascus, which is still thick-walled. The figures given by Miyabe and Sawada, of the Formosan specimens, illustrate the same condition. In the Ceylon gathering, some perithecia show asci and spores identical with the above description, but, in perithecia which contain free ascospores, the appearance is different. The asci have thin walls, but a thickened apex, and the walls and septa of the contained spores can only be detected with difficulty. The ascus, at first sight, appears to be filled with granular protoplasm, containing a large number of guttae. The extruded spores (Plate V, fig. 15) have thin walls and indistinct septa, and have granular contents with numerous large guttae. Zimmermann figures this condition of the ascospore in his specimen of *Ophionectria coccicola* from Java.

It would appear from the foregoing that the second state described is that of the mature ascospore, but there is no reference to any such condition in the North American publications which deal with this species.

It is generally agreed that *Scleroderris gigaspora* Massee, from Trinidad, is *Ophionectria coccicola*. There is no type specimen in Herb. Kew.

Podonectria Aurantii (v. Höhnel) Petch.

Von Höhnel described *Puttemansia Aurantii* as follows:

Sporodochia rounded, somewhat depressed globose, dark, white pruinose, 520–400 μ. Conidia in groups of 2 to 7, generally 3 to 4, on a basal cell, 8–10 × 5–6 μ. Single conidia hyaline, cylindrico-fusoid, straight, thick-walled, 130–180 × 8–9 μ, 18- to 23-septate, with an aseptate tip, 10–20 μ long.

Perithecia on a plectenchymatous stroma, which is up to 250 μ thick and gradually thins to the margin, clustered, white, woolly, globose, somewhat flattened above, 570 μ diameter including the woolly outer covering, 300–400 μ without it. Ostiolum minute on a naked disc; perithecia elsewhere densely clothed with hyaline, thick-walled, septate, flexuose, woolly hairs, up to 424 μ long and 3–4 μ diameter, which are often united into fascicles. Perithecial wall 30 μ thick. Asci cylindric, attenuated below, shortly stalked, with a foot, rounded at the apex, thick-walled (6–7 μ), 180–200 × 20 μ, eight-spored, spores biseriate. Paraphyses numerous, 1 μ diameter, longer than the asci. Spores hyaline, clavate, broadest at the upper end, lower end obtuse, thin-walled, 10- to 13-septate, not constricted, 66–80 × 8–10 μ: occasionally six-septate and 52 μ long.

On a scale insect on *Citrus Aurantium*, San Paulo, Brazil.

The following description of *Ophionectria tetraspora* was given by Miyabe and Sawada.

Sporodochia globose to obovoid, greyish white, mostly 3 to 6 on a scale, 0·3–0·8 mm. diameter. Conidiophores densely packed together, moniliform, bearing 3 to 5, mostly 4, conidia on the apical cell. Conidia become free, connected together by the apical cell. Single conidium cylindrical, slightly tapering towards the acute or obtuse tip, subclavately cylindrical when half matured, 12- to 20-septate, 105–190 × 7–9·5 μ.

Perithecia caespitose, subglobose to obovoid, darkish brown, about 0·5–0·6 mm. high, 0·5 mm. diameter. Asci fasciculate, clavate, rounded at the tip, hyaline, 150–177 × 17–20 μ, with thread-like paraphyses. Ascospores eight in an ascus, clavate, hyaline to straw-coloured, 11- to 17-septate, 50–64 × 6·5–7·5 μ.

On *Parlatoria zizyphi* (Lucas) Sign., infesting *Citrus nobilis* Lour., Formosa.

Miyabe and Sawada stated that the distinguishing character of their species is the production of four conidia on the apical cell of the conidiophore, although cases of three or five occasionally occur. It was also distinguished from *Ophionectria coccicola* by the shape of the conidia, the size and shape of the asci and ascospores, and the shape of the perithecia.

From the figures and description, the chief differences would appear to be the number and shape of the conidia, and the size of the ascospores. With regard to the former, Ceylon specimens of *Ophionectria coccicola* show conidia chiefly in fours, with acute or rounded tips, associated with perithecia, which contain long ascospores. It does not appear possible, therefore, to separate *Ophionectria tetraspora* on conidial characters.

A specimen of *Ophionectria tetraspora*, on *Parlatoria zizyphi* on *Citrus nobilis*, Taihoku, Formosa, *ex* Herb. Sapporo, has been kindly submitted to me by Prof. Ito. The sporodochium is subglobose, about 0·5 mm. high, flattened above, with a base about 0·4 mm. diameter, contracted just below the head of conidia. The base is brown, and the conidia form a white flattened disc-like head. The number of spores in a cluster varies from two to five, with a predominance of fours and threes. Individual spores vary from 60 to 160 μ in length, and their tips may be either long and acute, or rounded. Some have abnormally inflated globose tips. If the shape of the sporodochium is constant, it differs from that of *Ophionectria coccicola* in being globose, not columnar, and in having the head flattened instead of conoid.

The perithecia of *Ophionectria tetraspora* (Plate IV, fig. 10) are

globose, 0·5 mm. diameter, white, or brownish white, floccose, with an outer coat of interwoven hyphae and numerous free spreading hyphae. The latter are 3–4 μ diameter, thick-walled, somewhat irregular, up to 150 μ long, and sometimes united into fascicles. The asci measure up to 230 × 20 μ. The paraphyses exhibit distinct light and dark lengths, a feature which may also be observed in *Ophionectria coccicola*, though it is not so prominent in that species. Extruded spores from one ascus measured 74–86 × 6–8 μ; in another ascus one spore was only 66 μ long. The spores are fusoid, apex subacute, base strongly attenuated, up to 14-septate.

Although I have not seen the type specimen of *Ophionectria Aurantii*, I have little hesitation in referring *Ophionectria tetraspora* to that species. In the Formosan specimens, the free hyphae appear to be less profusely developed than in the Brazilian specimens described by von Höhnel.

Parkin recorded, from Ceylon, a *Calonectria* on *Mytilaspis citricola* on orange, and another on *Chionaspis vitis* on *Loranthus*. Of the former, he stated that the perithecia were pale brown, on a small mat of hyphae, with asci 70–84 × 6–8 μ, and spindle-shaped ascospores, with two conspicuous and two inconspicuous septa, 30–46 × 6·5–7 μ. The perithecia of the latter were dark brown, 320 μ diameter, with asci 85 × 16 μ, and five-septate spores, 55 × 7·5 μ. These specimens are not now available, but it would appear probable that they were immature *Podonectria*, and from the dimensions of the spores, *Podonectria Aurantii*.

Podonectria echinata n.sp.

This species was collected on *Lepidosaphes* on Pumelo (*Citrus nobilis*) at Peradeniya, October 1919. Its conidial stage resembles that of *Podonectria Aurantii*, but the perithecia appear sufficiently distinct to constitute a new species.

The stroma is purple-brown, of matted hyphae, not extending far beyond the scale in the specimens available. The majority of the stromata bear perithecia only. The perithecia (Plate IV, fig. 7) are scattered or clustered, globose, about 0·15 mm. diameter, ostiolum not evident, pale yellow, covered with projecting, white, triangular, or conical fascicles of hyphae up to 200 μ long, and 20 μ diameter. The hyphae of the stroma are hyaline, about 4 μ diameter and thick-walled: those of the projecting fascicles are about 3 μ diameter, and are united into a parallel bundle. These bundles arise as isolated tufts from the perithecial wall. The wall of the perithecium is hyaline, rather thin, and composed of somewhat small cells. The asci vary in the same way as those of *Podonectria coccicola*. They are clavate,

with a short, thick pedicel, eight-spored, with biseriate spores; but while some are thick-walled, 116–134 × 20–24 μ, and show clearly the septate ascospores, others are thin-walled, slightly thicker at the apex, 170–190 × 24 μ, and appear at first sight to be filled with a plasma which contains innumerable large guttae, the walls and septa of the ascospores being obscure. The paraphyses are filiform, branched and irregularly flexuose at the tips, rather scanty, and, as a rule, shorter than the asci. The ascospores are clavate, sometimes acute at the apex, usually strongly attenuated below, 8- to 14-septate, not constricted at the septa, hyaline, 64–82 × 7–9 μ.

The sporodochia have a shortly columnar base, up to 0·3 mm. diameter and 0·2 mm. high, brownish yellow, becoming brown, constricted above, with generally a flat white head, up to 0·4 mm. diameter. Sometimes the head is conical. They are sometimes arranged close together at the margin of the scale, and form a continuous border on one side. The conidia are borne in clusters of 2 to 4, and are narrow-cylindric, usually with long acuminate tips, multiseptate, 60–190 × 7–8 μ.

This species differs from *Podonectria Aurantii* (*O. tetraspora*) in the colour of the perithecia, the thin perithecial wall, and the spreading teeth. An examination of Broome's specimen of *Nectria aurantiicola* B. and Br., now in Herb. British Museum, showed that it contained this species in addition, but it is not included in the description of the former.

Tetracrium rectisporum (Cooke and Massee) Petch.

In Grevillea, XVI, p. 4 (1888), Cooke and Massee described *Microcera rectispora*, on a coccus on Citrus from Australia. It had straight, multiseptate spores, up to 200 μ long. Subsequently, Cooke, in Vegetable Wasps and Plant Worms, stated that this species did not differ much from *Microcera coccophila*, but he had described it as a new species in deference to the view that minute differences in the spores were of specific value. Cooke and Massee's description of the spore suggests *Tetracrium*, and that is confirmed by an examination of the type specimen. The type in Herb. Kew consists of three small pieces of bark; there are no sporodochia present, but examination under a low power shows that the bark is covered with scattered, detached, triad spores of *Tetracrium*. Curiously enough, this is the only gathering of *Tetracrium* or *Podonectria* known from Australia. Consequently it is uncertain to which species of *Podonectria* *Tetracrium rectisporum* should be assigned.

BROOMELLA.

Broomella Ichnaspidis Zimm.

This species was described from specimens on *Ichnaspis filiformis* on leaves of *Elaeis* and *Coffea liberica*, collected at Buitenzorg, Java. The following details are taken from Zimmermann's description and figure.

The fungus forms a stroma, about 0·8 mm. diameter, which partly envelopes the scale insect and extends slightly beyond it. The stroma is fleshy and bears protuberances, more or less cylindric and curved, up to 0·5 mm. high. Numerous globose perithecia occur in each stroma; they are at first embedded in the protuberances, but when mature become free for about half their height. The outer layers of the stroma are colourless and translucent, the inner layers blood red, the colouring matter being held by a finely granular substance and fading on heating with chloral hydrate.

The perithecia are sharply defined from the stromatic tissue; on heating with chloral hydrate the external part of the perithecial wall, and especially the ostiolum, remains dark brown. The asci are somewhat curved, eight-spored, 95–120 μ long. The ascospores are hyaline, appearing faintly brownish in the ascus, multiseptate (up to 15), linear, generally somewhat curved, almost as long as the ascus, 4–5 μ in diameter, tapering towards the base.

Zimmermann also described a variety *major*, which occurred on a Diaspid on leaves of *Pierardia* at Buitenzorg. It differed in having asci up to 170 μ long, and ascospores up to 155 μ long, approximately of equal thickness at either end.

I have not met with any specimens of this species. It is clear that the fungus is not a *Broomella*, but nearer a *Podonectria* with a well-developed stroma. It differs from *Podonectria* in having the perithecia partly embedded in the stroma. The spore figured by Zimmermann resembles that of *Podonectria coccicola*. The description of the colour of the perithecium recalls that of *Calonectria coccidophaga*, but that of the spores is quite different.

FUSARIUM.

Fusarium epicoccum was described by McAlpine in Fungus Diseases of Citrus Fruits in Australia (1899). It was found on Red Scale, *Aspidiotus aurantii*, on branches of Mandarin orange at Burnley, near Melbourne.

McAlpine stated that it grew round the margin and on the top of the scale, usually forming crescent-shaped, effused, pale brick-red masses. The hyphae (? conidiophores) were hyaline, septate, branched, slender, 2·5–3·5 μ diameter. The conidia

were hyaline, sickle-shaped, sometimes straight, acute at both ends, one- to three-septate, 17–19 × 2·5 μ, borne terminally and laterally on the conidiophores.

The type specimen was scanty, and it is now represented by two slides in Herb. Victoria. From these slides and McAlpine's figures, it would appear that the fungus formed a thin byssoid stroma which spread over the scale and from the scale over the host plant. The margin of the stroma shows a fringe of conidiophores, but the main mass of the conidiophores appears to have been compact, and to have formed a sporodochium, parenchymatous at the base, bearing close-packed conidiophores, either simple, or branched at the base, or repeatedly branched. The latter resemble the conidiophore figured by Sawada for *Fusarium Aspidioti*. The conidia (Plate V, fig. 19) are usually terminal on the branches, but a few arise laterally below the septa, the branch apparently being suppressed. The conidiophores are up to 50 μ high. The conidia vary from almost straight with falcate tips to uniformly and strongly curved; they are three-septate, with obtuse tips. The curved conidium resembles that found in *Sphaerostilbe aurantiicola.*

PATOUILLARDIELLA.

A fungus referable to this genus has been found on an Aleyrodid in Ceylon on one occasion. Its description is as follows:

Patouillardiella Aleyrodis n.sp.

Sporodochia superficial, oval in plan, flattened pulvinate, up to 0·7 mm. long, 0·5 mm. broad, and 0·3 mm. high, orange, central mass of spores slightly darker, waxy, towards the edge radiately floccose, with a fimbriate margin. Base of sporodochium parenchymatous. Conidiophores short, stout, once or twice branched, segments slightly inflated. Conidia hyaline, cylindric, ends rounded, one-septate, not constricted, 12–18 × 1·5–2·5 μ.

On an Aleyrodid on *Ochlandra*, Gikiyanakande, Ceylon, June 1916.

Trabut, in Bull. Agric. Alger et Tunisie, 1907, p. 32, described *Microcera Parlatoriae* which occurred on *Parlatoria zizyphi* on orange, Algiers, Oct. 1907. I am indebted to Prof. Patouillard for the record of this species and an authentic specimen from Trabut. The sporodochia are discoid, flat, circular, or pulvinate, 100–200 μ diameter, compact, now orange yellow, with a slight byssoid basal weft of hyphae, situated on or at the side of the scale. The conidiophores are of the same type as in *Fusarium epicoccum*, but the branches are slightly thinner. The conidia are stout, one- to three-septate, slightly curved, or strongly curved, or hooked, 16–21 × 3·5–4 μ, and are identical with

those of *Fusarium epicoccum*. This species is *Fusarium*, not *Microcera*, and it must be referred to *Fusarium epicoccum*.

In 1909, Saccardo (Ann. Myc. VII, p. 437) described *Microcera curta* on scale insects on *Tilia platyphylla*, collected at Tamsel, Germany. The sporodochia were described as gregarious, depressed-globose, 0·5–0·75 mm. broad, reddish, rather compact, shining; and the conidia as cylindric, curved at either extremity but principally at the apex, obtuse, three-septate, not constricted, 20–25 × 4–5 μ. I have examined the specimen, Sydow, Mycotheca Germanica, No. 849, in Herb. British Museum. The sporodochia are flattened-pulvinate, compact, and somewhat waxy-looking. The conidia are chiefly strongly and uniformly curved, a few being somewhat hookshaped. This species is indistinguishable from *Fusarium epicoccum*.

Patouillard, in Bull. Soc. Myc. France, XXVIII (1912), p. 142, described *Microcera Tonduzii* on an undetermined coccid on *Ficus*, San José, Costa Rica. The sporodochia were said to be fleshy, red, conical, about 200 μ high, 120 μ diameter, composed of close-packed, fuscous or rosy-red hyphae, 4–6 μ diameter. The conidia were curved, like a horse-shoe, with acute tips, hyaline, three-septate, scarcely or not constricted, 15–21 × 4 μ. On part of the type specimen kindly submitted to me by Prof. Patouillard, I was unable to distinguish sporodochia, but conidia were present. These conidia were falcate, or unequally, curved (hooked), or strongly and equally curved, the latter being the horse-shoe conidia of the original description; they were stout, three-septate, with obtuse tips, 15–17 × 4 μ. These conidia are those of *Fusarium epicoccum* and I have little doubt that *Microcera Tonduzii* must be referred to that species.

Sawada, in 1914, described *Fusarium Aspidioti* in a paper (in Japanese) on Some Remarkable Parasitic Fungi on Insects found in Japan. The sporodochia were situated at the margin of the scale, and were circular, or long-elliptic, pulvinate, reddish, 0·2–0·8 mm. long, 0·2–0·3 mm. broad. The conidiophores (Plate V, fig. 23) were much branched, the terminal branches being 21–28 × 2·5–3 μ. The conidia were acrogenous, cylindric, strongly curved, rounded or obtusely pointed at the ends, hyaline, three-septate, 24–29 × 3·5–4·5 μ. It occurred on *Aspidiotus perniciosus* on *Pyrus communis*, Shizuoka, Honshu.

I have not seen the type of *Fusarium Aspidioti*. On a leaf of *Citrus nobilis* from Taihoku, Formosa, April 25, 1911 (*ex* Herb. Sapporo) there occurred a *Fusarium* in company with *Podonectria coccicola*, *Pseudomicrocera Henningsii*, and *Microcera aurantiicola*, on the insects *Parlatoria zizyphi* Lucas and *Lepidosaphes Gloverii* Pack. It formed an effused, white, byssoid patch overrunning the scales. There was no pulvinate sporo-

dochium, the conidiophores occurring in small clusters here and there on the byssoid stroma. The conidiophores resembled those figured by Sawada, and the conidia were either slightly curved, or strongly and equally curved, or unequally curved and somewhat hook-shaped, stout, three-septate, with obtuse tips, 14–21 × 3·5–4 μ. This specimen was undoubtedly *Fusarium epicoccum*. Sawada's species has the same conidiophores and conidia, but his measurements of the length of the conidia are greater. The latter difference might be accounted for, if the measurements were taken along the curve. On the available evidence, it would seem that *Fusarium Aspidioti* is identical with *Fusarium epicoccum*.

The equally-curved, or horse-shoe-shaped conidium exactly resembles the small curved conidium which often occurs with the perithecia or synnemata of *Sphaerostilbe aurantiicola*, and has been found in one gathering of *Sphaerostilbe flammea*. This suggests that either *Fusarium epicoccum* is a stage of *Sphaerostilbe*, or that the small *Fusarium* conidium found with the *Sphaerostilbe* is intrusive. Against the latter supposition, there is the fact that these conidia are not found in association with other species of scale insect fungi, as might be expected if their occurrence were accidental. And against the former, no sporodochia of *Fusarium epicoccum* have been found in company with *Sphaerostilbe aurantiicola*, and, with one exception, all the gatherings of *Fusarium epicoccum* do not bear any other fungus. The exception is the specimens from Formosa referred to above, and in that instance the mixture of fungi on the leaf prevents any deduction.

Fawcett described what he considered to be a new species of *Microcera* in his paper on the Fungi parasitic on *Aleyrodes citri* (1908). He stated that the fungus formed a fringe of delicate, white hyphae growing outward from the edge of the scale, and producing one-, two-, or three-celled conidia, oval to fusiform in shape. Afterwards pinkish spore masses, made up of a compact mass of lunate conidia were formed on the edge of the scale. The first conidia measure 7–12 × 3 μ; the lunate conidia are acute at both ends, three- to five-septate, and measure 28–40 × 3·5–5 μ, with a few, 52 μ.

In a specimen from Fawcett, the conidiophores form a fringe round the scale: they are up to 100 μ long, with distant, solitary, lateral branches and terminal conidia. The conidia (Plate V, fig. 12) are straight, or slightly curved, subcymbiform, ends acute, three- to four-septate, 16–50 × 4–6 μ.

This species is a *Fusarium*, but distinct from the foregoing. It may be known as *Fusarium Aleyrodis*.

SYSTEMATIC LIST

HYPOCREACEAE.

NECTRIA.

Nectria diploa B. and C., Jour. Linn. Soc. x (1868), p. 378; *Nectria coccorum* Speg., Fungi Guaranitici, Pug. 1, No. 234 (? 1886); *Nectria coccogena* Speg., Fungi Puigg., No. 289 (1889); *Nectria oidioides* Speg., *myrticola* Rehm, Ule, Herb. Brasiliense, No. 1288; ? *Nectria coccophila* Nomura, Imp. Agric. Expt. Sta., Rep. 18, p. 105 (1901); ? *Nectria variabilis* Hara, Bot. Mag. XXVIII, p. 339 (1914).

Conidial stage—*Pseudomicrocera Henningsii* (Koorders) Petch; *Aschersonia Henningsii* Koord., Bot. Untersuch. (1907), p. 213; *Microcera Fujikuroi* Miyabe and Sawada, Jour. Coll. Agric., Tohoku Imp. Univ., Sapporo, v, pt. 3 (March 1913), pp. 73–90; *Microcera Merrillii* Syd., Ann. Myc., XII, p. 576 (1914); *Microcera Henningsii* (Koord.) Petch, Ann. Perad., v, p. 533 (1914).

Exsiccati. Balansa, Pl. de Paraguay, 4046; Roumeguère, Fungi Selecti Exsicc., 5229; Roumeguère, Fungi Gallici Exsicc., 3547; Ule, Herb. Brasiliense, 1288.

Perithecia clustered on the old conidial stroma, globose, up to 0·4 mm. diameter, bright red, darker round the ostiolum, covered with large warts up to 0·1 mm. high which are sometimes confluent and form a continuous crust; old herbarium specimens orange red or orange yellow; ostiolum minute, conical; asci clavate, sessile, 4-spored, 64–68 × 12 μ or eight-spored, 96–116 × 10–14 μ; ascospores pale yellow, elliptical, narrow-oval, or subcymbiform, ends obtuse, one-septate, not constricted at the septum, 16–32 × 6–9 μ.

Stroma compact yellowish white, or pinkish red, surrounding the scale; sporodochia horizontal or oblique consisting of a red, pulvinate, or subglobose base, up to 0·6 mm. broad and 0·5 mm. high, surmounted by a white conical tip, up to 0·6 mm. high: conidiophores branched, up to 60 μ long; conidia hyaline, arcuate, regularly curved, acute, three- to five-septate, 40–100 × 3–5 μ: in var. *longispora*, 92–134 × 3 μ.

Distribution. Perithecial stage—Cuba-Brazil; Paraguay; Ceylon; Mauritius. Conidial stage—Brazil, Paraguay; Florida; Cuba; Grenada (W.I.); Ceylon; India; Java; Mauritius; Burma; Australia; Philippines; Formosa; West Africa (var. *longispora*).

Nectria Tuberculariae Petch n.sp.

Perithecia scattered or clustered, on the scale, or on a white byssoid stroma, or in the sporodochia, globose, pale flesh coloured, white pruinose, 0·2 mm. diameter; ostiolum minute, conical; asci cylindric, eight-spored, spores obliquely uniseriate,

50–62 × 4 μ; ascospores oval or oblong-oval, one-septate, not constricted, hyaline, minutely warted, 6–9 × 2·5–5 μ.

Conidial stage—*Tubercularia coccicola* Stev., Ann. Rep. Ins. Expt. Sta. Porto Rico, 1917.

Sporodochia scattered or clustered, flattened pulvinate, compact, 0·5–4 mm., sometimes confluent, with or without a white byssoid stroma, pink, becoming white when old; conidiophores branched, up to 36 μ long; conidia cylindric with rounded ends, up to 6 × 2·5 μ, or oval, 3–5 × 2–3 μ, or globose, 2·5 μ diameter, hyaline, continuous.

Distribution. Perithecial stage—Ceylon; India. Conidial stage—Ceylon; India; Porto Rico.

Nectria barbata Petch, n.sp.

Perithecia scattered, conoid or subglobose, 0·2 mm. diameter, 0·3 mm. high, yellow brown or dark amber, subtranslucent, minutely rugose, collapsing, with a ring of erect, white, rigid hairs below the ostiolum; ostiolum broadly papillate or obtusely conical; hairs up to 50 μ high, 4 μ diameter, equal, or slightly inflated at the tip; asci cylindrico-clavate, eight-spored, spores uniseriate, obliquely uniseriate, or transverse, 66 × 6–8 μ; ascospores hyaline, oblong-oval, ends broadly rounded, one-septate, strongly constricted, 6–8 × 3–5 μ.

Distribution. Ceylon.

LISEA.

Lisea Parlatoriae Zimm., Centralb. f. Bakt., Abt. 2, VII (1901), p. 873.

Perithecia crowded, superficial, globose, 0·2–0·25 mm. high, and 0·15–0·18 mm. diameter, black; ostiolum papillate; wall dark violet to black by transmitted light; asci cylindric, eight-spored; ascospores elliptic, obtuse, one-septate, not constricted, hyaline or slightly brownish, 9–12 × 4·5 μ.

Distribution. Java.

SPHAEROSTILBE.

Sphaerostilbe aurantiicola (B. and Br.) Petch, Ann. Perad., VII, p. 119 (1920); *Nectria aurantiicola* B. and Br., Jour. Linn. Soc., XIV, p. 117 (1873); *Sphaerostilbe coccophila* Tul. (1865), quoad Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda, Nos. 262, 269; *Corallomyces aurantiicola* (B. and Br.) v. H., Frag. zur Myk., XIV, No. 729.

Conidial stage—*Microcera aurantiicola* Petch.

Exsiccati. Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda, Nos. 262, 269; Erbar. Crittogam. Ital., Nos. 539, 543, Ser. II, 542; Ravenel, Fungi Amer. Exsicc., No. 286.

Perithecia usually scattered, without evident stroma, at first orange red, becoming blood red, darker round the ostiolum,

subtranslucent, sometimes with a few yellow granules, usually smooth, subglobose or subconoid, 0·2–0·25 mm. diameter, collapsing laterally; ostiolum papillate or not elevated; asci cylindro-clavate, scarcely pedicellate, eight-spored, spores uniseriate or obliquely uniseriate, 66–90 × 6–8 μ; paraphyses diffluent; ascospores oval, obtuse, hyaline to yellowish, one-septate, not constricted, wall rather thick and minutely warted, 9–14 × 4–6 μ.

Synnemata stilboid or clavate, up to 2 mm. high, 0·4 mm. diameter below, 0·6 mm. diameter above, or flattened pulvinate, sessile, up to 0·6 mm. long, 0·4 mm. broad, orange red to blood red, subtranslucent, becoming hard and horny when dry, arising from a narrow yellowish white loose stroma; conidia narrow cylindric, tapering at the ends, straight or slightly curved, ends falcate, hyaline or yellowish, up to eleven-septate, septa usually distinct, 70–120 × 5–7 μ. A small strongly curved *Fusarium* conidium, three-septate, obtuse, hyaline, 12–18 × 3–4 μ is often present.

Distribution. Ceylon; India; Madagascar; Japan; Formosa; Dominica (W.I.); Georgia (U.S.A.); Florida (U.S.A.); Italy.

Sphaerostilbe flammea Tul., Selecta Carp. Fung. I, p. 130 (1861); *Stilbum flammeum* Tul., Acta hebdom. Acad. Sci. par., XLII, p. 704, et Ann. Sci. Nat., Ser. 4, vol. V (1856), p. 114; *Nectria muscivora* Berk., Ravenel, Fungi Car. Exsicc., No. 57, non *Nectria muscivora* B. and Br., Ann. Mag. Nat. Hist., Ser. 2, vol. VII, p. 188 (1851); *Nectria lacticolor* B. and C., Jour. Linn. Soc. X (1868), p. 377; *Nectria aglaothele* B. and C., Grevillea IV, p. 45 (1875); *Nectria subcoccinea* Sacc. and Ellis, Michelia, II, p. 570 (1882); *Nectria Passeriniana* Cooke, Grevillea, XII, p. 81 (1884); *Sphaerostilbe coccophila* Tul. (1865), quoad Desmazières, Plantes Crypt. de France, Ed. II, Ser. I, No. 1350 and Ed. I, Ser. I, No. 1750.

Conidial stage—*Microcera coccophila* Desm., Ann. Sci. Nat., Ser. 3, vol. X (1848), p. 539; *Atractium flammeum* Berk. and Rav. Ann. Mag. Nat. Hist., Ser. 2, vol. XIII (1854), p. 461; *Microcera pluriseptata* Cke. and Massee, Grevillea, XVII, p. 43; ? *Fusarium coccinellum* (Kalch.) Thuem., Mycotheca Univ., No. 782, *Fusisporium coccinellum* Kalch., Flora, LIX (1876), p. 426.

Exsiccati. Desmazières, Plantes Cryptogames de France, Ed. I, Ser. I, No. 1750, and Ed. II, Ser. I, No. 1350; Ravenel, Fungi Car. Exsicc., No. 57 and V. No. 86; Fungi Cubenses Wrightiani, No. 765; Ellis, North American Fungi, Nos. 1229 and 1333; Cooke, Fungi Brit. Exsicc., No. 350, and Ed. II, No. 534; ? Thuemen, Mycotheca Univ., No. 782.

Perithecia usually clustered on a well-developed plectenchymatous stroma, bright orange red, darker round the ostiolum,

glabrous, slightly rugose, opaque, globose, 0·3 mm. diameter, usually collapsing centrally; ostiolum minute, conical, or scarcely evident; asci cylindric, scarcely pedicellate, eight-spored, spores obliquely uniseriate, 90–116 × 8–10 μ; paraphyses diffluent; ascospores elliptic, obtuse, one-septate, not constricted, hyaline, or yellowish, minutely warted, 12–19 × 5–8 μ.

Synnemata arising from a white or pinkish stroma round the scale, stilboid up to 2·5 mm. high, more usually clavate or conical, up to 0·6 mm. high, 0·25 mm. diameter, or flattened pulvinate, up to 0·75 mm. long, 0·5 mm. broad, orange red to blood red, usually clothed with erect fascicles of hyphae at the base; conidia fusiform, straight, or straight with falcate tips, or slightly curved, up to eleven-septate, but usually with few, irregularly spaced, and obscure septa, hyaline, 50–105 × 5–7 μ, sometimes only 35 μ long. A small strongly curved *Fusarium* conidium, three-septate, obtuse, hyaline, 18 × 4 μ, is sometimes present.

Distribution. United States (Pennsylvania; Massachusetts; South Carolina; Georgia; Louisiana; Texas; Florida); Cuba; Brazil; Argentina; France; England; Italy; ? South Africa; ? New Zealand; ? Australia.

Sphaerostilbe coccidophthora (Zimm.) Petch, Ann. Perad., VII, p. 131 (1920); *Nectria coccidophthora* Zimm., Centralb. f. Bakt., Abt. II, VII, p. 873 (1901).

Conidial stage—*Microcera coccidophthora* Petch.

Perithecia scattered or clustered, sometimes on a narrow floccose stroma, orange red becoming blood red, darker round the ostiolum, subtranslucent, covered with yellow or yellowish red granules, subglobose or subconoid, collapsing laterally; ostiolum usually papillate; asci cylindrico-clavate, shortly pedicellate, eight-spored, spores obliquely uniseriate, 84–136 × 8–10 μ; paraphyses linear, diffluent; ascospores oval or broadly oval, obtuse, hyaline to yellowish, one-septate, not constricted, wall thick and minutely warted, 13–22 × 7–9 μ.

Synnemata arising from a narrow yellowish white, loose, floccose stroma round the scale, clavate, up to 1·4 mm. high, 0·25 mm. diameter below, 0·3 mm. diameter above, or subsessile, ovoid or conical, up to 0·4 mm. high, 0·25 mm. diameter, orange red to blood red, pale towards the base, subtranslucent when fresh, becoming hard and horny when dry; conidia cylindric, tapering at the ends, almost straight, tips falcate, hyaline, up to eleven-septate, usually with large numbers of aseptate conidia, 62–106 × 6–7 μ.

Distribution. Ceylon; India; Java; Seychelles.

CALONECTRIA.

Calonectria coccidophaga Petch n.sp.

Conidial stage—*Discofusarium tasmaniense* (McAlp.) Petch; *Microcera tasmaniensis* McAlp., Agric. Jour. Victoria, II (1904), pp. 646–648; *Microcera Mytilaspis* McAlp., *loc. cit.*

Perithecia clustered, on a parenchymatous, yellowish stroma, globose, 0·4 mm. diameter, horny-looking, black above, pinkish-yellow below, pruinose except at the apex; apex papillate or flat and discoid with a punctiform ostiolum; wall thick, rose red in section; asci clavate, eight-spored, spores biseriate above, uniseriate below, 120–140 × 14–16 μ; paraphyses stout, branched; ascospores oblong-oval or subcymbiform, straight or curved, obtuse, three-septate, constricted at the septa, 22–34 × 8–9 μ.

Sporodochia clustered, sessile, pulvinate or subglobose, up to 0·3 mm. diameter, or discoid, up to 0·8 mm. long, 0·6 mm. broad, sessile or shortly stalked, salmon pink when fresh, becoming yellow with a white margin in herbarium specimens; conidiophores short, repeatedly branched, with short, slightly inflated segments; conidia fusiform, slightly falcate or almost straight, obtuse, up to five-septate, hyaline, 30–58 × 4–6 μ.

Distribution. Victoria; Tasmania.

PODONECTRIA GEN. NOV.

Perithecia on a byssoid stroma, nectriaceous; asci thick-walled, spores biseriate; ascospores elongated fusiform, multiseptate, hyaline; conidial stage, *Tetracrium.*

Podonectria coccicola (E. and E.) Petch; *Nectria* (*Ophionectria*) *coccicola* E. and E., Jour. of Myc. II, p. 39 (1886); *Dialonectria coccicola* E. and E., Jour. of Myc., II, p. 137 (1886); *Ophionectria coccicola* (E. and E.) Berl. and Vogl., Saccardo, Syll., Add. IV, p. 218 (1886); *Scolecconectria coccicola* (E. and E.) Seaver, Mycologia, I, p. 198 (1909); *Puttemansia coccicola* (E. and E.) v. Höhnel, Fragm. zur Myk., XIII, p. 30 (1911); *Sclerodcrris gigaspora* Massee, Kew Bulletin (1910), p. 3.

Conidial stage—*Tetracrium coccicolum* v. Höhnel, *loc. cit.*

Perithecia on a byssoid stroma, ovoid or subglobose, sometimes turbinate, up to 0·5 mm. high, 0·4 mm. diameter, brown or blackish brown, minutely rugose, glabrous, ostiolum obscure; wall parenchymatous very thick; asci clavate, shortly pedicellate, pedate, thick walled, eight-spored, spores biseriate, 200–290 × 20–28 μ; paraphyses numerous, filiform, branched; ascospores fusoid or clavate, obtuse, hyaline, multiseptate, 80–176 × 7–8 μ.

Sporodochia consisting of a brown, cylindric or ovoid, parenchymatous base, up to 0·6 mm. high, 0·4 mm. diameter, sur-

mounted by a white subconical head of conidia; conidiophores short, moniliform; conidia detached in clusters of two to five, united at the base by a small lozenge-shaped cell; individual conidia hyaline, cylindric, multiseptate, usually with a long aseptate acuminate tip, sometimes equal, obtuse and rounded at the apex, 50–256 × 7–9 μ.

Distribution. Ceylon; Java; Formosa; Zululand; Florida; Dominica (W.I.).

Podonectria Aurantii (v. Höhnel) Petch; *Puttemansia Aurantii* v. Höhnel, Fragmente zur Mykologie, XIII (1911), p. 28; *Ophionectria tetraspora* Miyabe and Sawada, Jour. Coll. Agric., Tohuku Imp. Univ., Sapporo, V, pt. 3 (March 1913), p. 85.

Conidial stage—*Tetracrium Aurantii* P. Henn., Hedwigia, XLI (1902), p. 116.

Perithecia on a byssoid stroma, globose, 0·5 mm. diameter, white or brownish white, floccose, densely clothed with thick-walled, irregular, septate, hyaline hyphae which are sometimes united into fascicles; ostiolum minute on a naked disc; wall thick, parenchymatous; asci clavate, thick-walled, shortly pedicellate, pedate, eight-spored, spores biseriate, 150–230 × 20 μ; paraphyses numerous, filiform, branched; ascospores fusoid or clavate, obtuse, hyaline to yellowish, multiseptate, 66–86 × 7–10 μ.

Sporodochia with a globose or obovoid brown base, about 0·5 mm. high, 0·4 mm. diameter, with a flattened disc-like white head of conidia (in the specimens examined); conidiophores short moniliform; conidia detached in clusters of two to five, united at the base by a small lozenge-shaped cell; individual conidia cylindric, hyaline, multiseptate, with long, acute, aseptate tips, or equal and rounded at the apex, 60–190 × 7–9 μ.

Distribution. Brazil; Formosa.

Podonectria echinata Petch n.sp.

Conidial stage—*Tetracrium echinatum* Petch n.sp.

Perithecia on a byssoid stroma, globose, about 0·15 mm. diameter, pale yellow, clothed with white, triangular or conical, projecting fascicles of hyphae up to 200 μ long and 20 μ diameter; ostiolum not evident; wall rather thin, hyaline by transmitted light; asci clavate, thick-walled, shortly pedicellate, pedate, eight-spored, spores biseriate, 116–190 × 20–24 μ; paraphyses numerous, filiform, branched; ascospores clavate, sometimes acute at the apex, usually strongly attenuated below, multiseptate, hyaline, 64–82 × 7–9 μ.

Sporodochia with a short columnar base, up to 0·3 mm. diameter, 0·2 mm. high, constricted above, brownish yellow, becoming brown, generally with a flat discoid head of conidia, up to 0·4 mm. diameter; conidiophores short moniliform; conidia

detached in clusters of two to four, united at the base by a small lozenge-shaped cell; individual conidia cylindric, hyaline, multiseptate, usually with long, acuminate, aseptate tips, 60–190 × 7–8 μ.

Distribution. Ceylon.

BROOMELLA.

Broomella Ichnaspidis Zimm., Centralb. f. Bakt., Abt. 2, VII (1901), p. 874.

Stroma about 0·8 mm. diameter, fleshy, outer layers colourless, inner layers blood red, tuberculate, tubercles more or less cylindric and curved and up to 0·5 mm. high; perithecia at first embedded in the tubercles, becoming free for half their height; asci somewhat curved, eight-spored, 95–120 μ long; ascospores hyaline or with a brown tinge, multiseptate, linear, generally somewhat curved, tapering towards the base, almost as long as the ascus, 4–5 μ diameter.

var. *major*. Asci up to 170 μ long; ascospores up to 155 μ long, of equal thickness at either end.

Distribution. Java.

STILBACEAE.

MICROCERA.

Microcera aurantiicola Petch.

Conidial stage of *Sphaerostilbe aurantiicola* (B. and Br.) Petch, see p. 124.

Microcera coccophila Desm., Ann. Sci. Nat., Ser. 3, vol. X (1848), p. 359; *Atractium flammeum* Berk. and Rav., Ann. Mag. Nat. Hist., Ser. 2, vol. XIII (1854), p. 461; *Microcera pluriseptata* Cke. and Massee, Grevillea, XVII, p. 43 (1888); ? *Fusarium coccinellum* (Kalch.) Thuem., Mycotheca Univ., No. 782, *Fusisporium coccinellum* Kalch, Flora, LIX (1876), p. 426.

Conidial stage of *Sphaerostilbe flammea* Tul., see p. 115.

Microcera coccidophthora Petch.

Conidial stage of *Sphaerostilbe coccidophthora* (Zimm.) Petch, see p. 129.

TUBERCULARIACEAE.

TUBERCULARIA.

Tubercularia coccicola Stevenson, Ann. Rep. Ins. Exp. Sta., Porto Rico 1917.

Conidial stage of *Nectria Tuberculariae* Petch; see p. 157.

PATOUILLARDIELLA.

Patouillardiella Aleyrodis Petch, n.sp.

Sporodochia oval, flattened pulvinate, up to 0·7 mm. long, 0·5 mm. broad, 0·3 mm. high, orange, central mass of conidia slightly darker, waxy, towards the edge radiately floccose with

a fimbriate margin; conidiophores short, stout, once or twice branched, segments slightly inflated; conidia hyaline, cylindric, ends rounded, one-septate, not constricted, 12–18 × 1·5–2·5 μ.

Distribution. Ceylon.

FUSARIUM.

Fusarium epicoccum McAlp., Fungus diseases of Citrus trees in Australia (1899); *Microcera Parlatoriae* Trabut, Bull. Agric. Alger et Tunisie, 1907, p. 32; *Microcera curta* Sacc., Ann. Myc., VII, p. 437 (1909); *Microcera Tonduzii* Pat., Bull. Soc. Myc. France, XXVIII (1912), p. 142; *Fusarium Aspidioti* Sawada, Bot. Mag., Tokyo, XXVIII, p. 312 (1914).

Sporodochium flattened pulvinate or discoid, up to 0·75 mm. diameter, pale red, sometimes seated on a white byssoid stroma, parenchymatous at the base; conidiophores simple or repeatedly branched, up to 50 μ long; conidia hyaline, stout, obtuse, up to three-septate, slightly curved, or curved at one end, or strongly curved, 16–25 × 2·5–4 μ.

Distribution. Australia; Japan; Algeria; Germany; Costa Rica.

Fusarium Aleyrodis Petch, n.sp.; *Microcera* sp., Fawcett, Fungi parasitic on Aleyrodes Citri (1908).

Stroma white, thin, byssoid; conidiophores scattered or clustered, up to 100 μ long, with distant, solitary lateral branches; conidia cylindric, straight or slightly curved, subcymbiform, acute, three- to four-septate, 16–50 × 4–6 μ.

Distribution. Florida.

PSEUDOMICROCERA GEN. NOV.

Sporodochia conical; base ovoid, cylindric, or pulvinate, parenchymatous, or composed of interwoven irregular hyphae, surmounted by a discoid layer of conidiophores with a marginal zone of long hyphae, which are united into a continuous sheet, or into fascicles of varying breadth which are connivent at the apex; conidiophores branched: conidia elongated, narrow, curved, septate, hyaline.

Pseudomicrocera Henningsii (Koord.) Petch; *Aschersonia Henningsii* Koord., Bot. Untersuch. (1907), p. 213; *Microcera Fujikuroi* Miyabe and Sawada, Jour. Coll. Agric., Tohuku Imp. Univ., Sapporo, V. pt. 3 (March 1913), pp. 73–90; *Microcera Merrillii* Syd., Ann. Myc., XII, p. 576 (1914); *Microcera Henningsii* (Koord.) Petch., Ann. Perad., V, p. 533 (1914).

The conidial stage of *Nectria diploa* B. and C.; see p. 157.

DISCOFUSARIUM GEN. NOV.

Sporodochium discoid, sessile or shortly stalked, the external layers composed of parallel hyphae continuous from the base,

extending above the disc and forming an incurved margin; disc composed of branched conidiophores; conidia hyaline, fusarioid, multiseptate.

Discofusarium tasmaniense (McAlp.) Petch; *Microcera tasmaniensis* McAlp., Agric. Jour. Victoria, II (1904), pp. 646–648; *Microcera Mytilaspis* McAlp., *loc. cit.*

The conidial stage of *Calonectria coccidophaga* Petch; see p. 161.

TETRACRIUM.

Tetracrium coccicolum v. Höhnel, Fragm. zur Myk., XIII, p. 30 (1911).

The conidial stage of *Podonectria coccicola* (E. and E.) Petch; see p. 161.

Tetracrium Aurantii P. Henn., Hedwigia, XLI (1902), p. 116.

The conidial stage of *Podonectria Aurantii* (v. H.) Petch; see p. 162.

Tetracrium echinatum Petch, n.sp.

The conidial stage of *Podonectria echinata* Petch; see p. 162.

Tetracrium rectisporum (Cke. and Massee) Petch; *Microcera rectispora* Cke. and Massee, Grevillea, XVI, p. 4 (1888).

The type specimen does not contain sporodochia or perithecia, but only scattered, detached conidial clusters of some *Tetracrium*.

EXPLANATION OF PLATES.

PLATE III.

Fig. 1. *Sphaerostilbe aurantiicola*, conidial (*Microcera*) stage, on *Aspidiotus*, Ceylon specimen. × 15.

Fig. 2. *Sphaerostilbe aurantiicola*, conidial (*Microcera*) stage, sessile form, on *Aspidiotus*, Ceylon specimen. × 10.

Fig. 3. *Sphaerostilbe aurantiicola*, perithecial stage, on *Aspidiotus*, Ceylon specimen. × 12.

Fig. 4. *Sphaerostilbe aurantiicola*, perithecium, Ceylon specimen. × 60.

Fig. 5. *Sphaerostilbe aurantiicola*, old conidial (*Microcera*) stage after most of the conidia have disappeared, showing the empty sheath at the apex, specimen from Formosa, on a scale on apple. × 12.

Fig. 6. *Sphaerostilbe coccidophthora*, perithecium, Ceylon specimen. × 60.

Fig. 7. *Sphaerostilbe flammea*, perithecial stage, *ex* herb. Spegazzini. × 15.

Fig. 8. *Sphaerostilbe flammea*, conidial (*Microcera*) stage, *ex* herb. Spegazzini. × 15.

Fig. 9. *Pseudomicrocera Henningsii*, on *Aonidia*, stroma circumferential, the central area of the scale not covered, sporodochium arising from the inner margin of the stroma, dry weather form, Ceylon. × 12.

Fig. 10. *Pseudomicrocera Henningsii*, on *Aonidia*, stroma confined to one side, dry weather form, Ceylon. × 12.

Fig. 11. *Pseudomicrocera Henningsii*, sporodochium with well-developed parenchymatous base, specimen from Florida. × 15.

Fig. 12. *Pseudomicrocera Henningsii*, on *Aspidiotus*, stroma marginal, base of sporodochium feebly developed, Ceylon. × 20.

Fig. 13. *Nectria diploa*, perithecia, with effete sporodochia, Ceylon. × 50.

Fig. 14. *Nectria barbata*, perithecium, Ceylon. × 80.

PLATE IV.

Fig. 1. *Discofusarium tasmaniense*, fully developed specimen *ex* type of *Microcera Mytilaspis*. × 12.
Fig. 2. *Discofusarium tasmaniense*, young specimens, *ex* type of *Microcera tasmaniensis*. × 12.
Fig. 3. *Calonectria coccidophaga*, group of perithecia, one cut open. × 12.
Fig. 4. *Calonectria coccidophaga*, group of old perithecia. × 12.
Fig. 5. *Tubercularia coccicola*, group of sporodochia on *Lepidosaphes*, with radiating marginal stroma, Ceylon specimen. × 12.
Fig. 6. *Tubercularia coccicola*, group of sporodochia on *Lepidosaphes*, the stroma covered by a *Septobasidium*, Ceylon specimen. × 12.
Fig. 7. *Podonectria echinata*, group of perithecia on *Lepidosaphes*. × 12.
Fig. 8. *Nectria Tuberculariae*, on *Lepidosaphes*. × 12.
Fig. 9. *Podonectria coccicola*, perithecia and sporodochium, on *Lepidosaphes*, specimen from West Indies. × 12.
Fig. 10. *Podonectria Aurantii*, perithecia and sporodochium (second from right), on *Parlatoria*, *ex* type of *Ophionectria tetraspora*, Formosa. × 10.

PLATE V.

Fig. 1. *Podonectria coccicola*, conidia, Glenugie, Ceylon. × 400.
Fig. 2. *Podonectria coccicola*, conidia, Zululand. × 400.
Fig. 3. *Podonectria coccicola*, conidia, Glenugie, Ceylon. × 400.
Fig. 4. Hairs from the perithecium of *Nectria barbata*. × 300.
Fig. 5. *Nectria barbata*, ascus. × 600.
Fig. 6. *Nectria barbata*, ascospores. × 600.
Fig. 7. *Calonectria coccidophaga*, ascospores. × 400.
Fig. 8. Sterile sheaths of *Pseudomicrocera Henningsii*. × 20; *a*, back view; *b*, lateral view; *c*, front view.
Fig. 9. *Nectria Tuberculariae*, ascospores. × 600.
Fig. 10. *Sphaerostilbe aurantiicola*, conidia. × 500.
Fig. 11. *Sphaerostilbe aurantiicola*, small curved conidium. × 500.
Fig. 12. Conidiophore and conidia of *Fusarium Aleyrodis*. × 400.
Fig. 13. Conidiophore and conidia of *Discofusarium Mytilaspidis*. × 350.
Fig. 14. *Podonectria Aurantii*, ascospore. × 400.
Fig. 15. *Podonectria coccicola*, ascospore (? mature form). × 400.
Fig. 16. Bases of the conidiophores of *Sphaerostilbe aurantiicola*, showing ladder connection. × 500.
Fig. 17. *Pseudomicrocera Henningsii*, conidia. × 600.
Fig. 18. *Nectria coccogena*, ascospore. × 500.
Fig. 19. *Fusarium epicoccum*, conidia, *ex* type. × 600.
Fig. 20. *Pseudomicrocera Henningsii*, form on *Aonidia*, Ceylon, viewed from the lower surface. × 12 (diagrammatic).
Fig. 21. *Pseudomicrocera Henningsii*, Florida, in longitudinal section. × 12 (diagrammatic).
Fig. 22. *Nectria diploa*, ascospores, Ceylon. × 500.
Fig. 23. *Fusarium Aspidioti*, conidiophores and conidia. × 400 (after Sawada).

BIBLIOGRAPHY.

COOKE, M. C.—Vegetable Wasps and Plant Worms, London, 1892. *Nectria coccorum* Speg., *Microcera coccophila* Desm., *Microcera rectispora* Cke. and Massee.

COOKE, M. C. and MASSEE, G. E.—[*Microcera rectispora*]. Grevillea, XVI, p. 4 (Sept. 1887).

DESMAZIÈRES, J. B. H. J.—Seizième notice sur les Plantes Cryptogames récemment découvertes en France. Ann. Sci. Nat., Ser. 3, vol. X (1848), p. 359. *Microcera coccophila* Desm.

ELLIS, J. B. and EVERHART, B. M.—[*Nectria coccicola* E. and E.]. Jour. Myc. II, p. 39 (1886); II, p. 137 (1886).

1

3

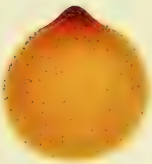
7

2

4

8

5



6

9

10

11

13

14

12

1

3

4

2

5

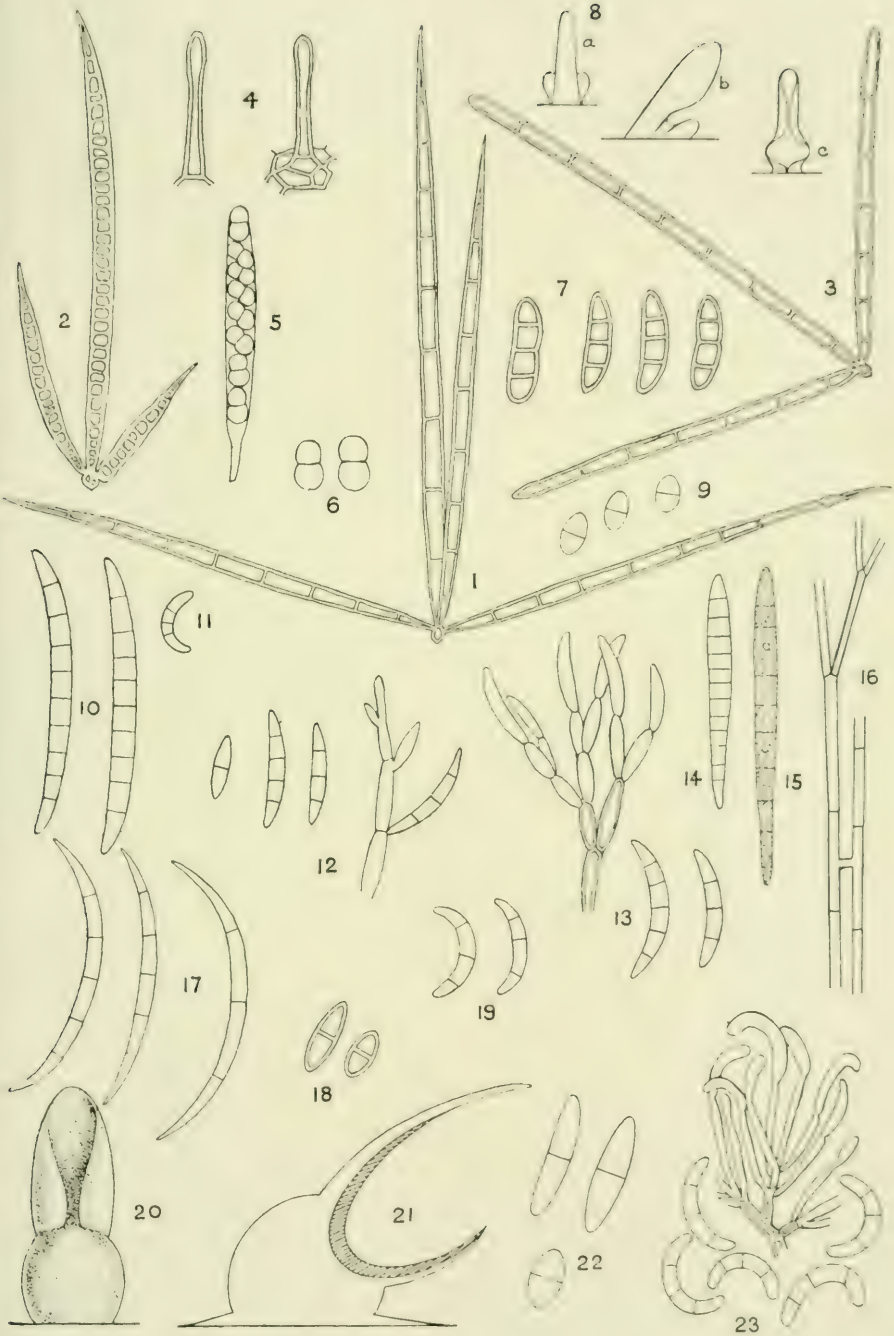
6

7

8

9

10


1
2
3
4
5
6
7
8
a
b
c
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

FAWCETT, H.—Fungi parasitic on *Aleyrodes citri*. University of the State of Florida, Special Studies, No. 1, June 1908. *Microcera* sp.

HARA, K.—On Fungi parasitic on Insects found in the Gifu Prefecture. Botanical Magazine, XXVIII, p. 339 (1914). *Nectria variabilis* Hara.

HENNINGS, P.—[*Tetracrium Aurantii* P. Henn.]. Hedwigia, XLI (1902), p. 116.

VON HÖHNEL, F.—Fragmente zur Mykologie, XIII, pp. 27–30 (1911). *Tetracrium Aurantii* P. Henn.; *Tetracrium coccicola* v. H.; *Puttemansia Aurantii* v. H.; *Puttemansia coccicola* (E. and E.) v. H.

—— —Fragmente zur Mykologie, XIV, No. 729 (1912). *Corallomyces aurantiicola* (B. and Br.) v. H.

VON HÖHNEL, F. and WEESE, J.—Zur Synonymie in der Gattung Nectria, II. Ann. Myc., IX, pp. 422–424 (1911).

MCALPINE, D.—Fungus diseases of Citrus trees in Australia, 1899. *Microcera coccophila* Desm.; *Microcera rectispora* Cke. and Massee; *Fusarium epicoccum* McAlp.

—— —Two new fungi parasitic on scale insects. Agric. Jour. Victoria, II, pp. 646–648 (May 1904). *Microcera tasmaniensis* McAlp.; *Microcera Mytilaspis* McAlp.

MIYABE, K. and SAWADA, K.—On fungi parasitic on scale insects found in Formosa. Jour. Coll. Agriculture, Tohoku Imperial University, Sapporo, V, pt. 3 (March 1913), pp. 73–90. *Sphaerostilbe coccophila* Tul.; *Microcera Fujikuroi* Miy. and Saw.; *Ophionectria coccicola* Ell. and Ev.; *Ophionectria tetraspora* Miy. and Saw.

NOMURA, H.—Scarlet fungus disease of scale insects. Imp. Agr. Exp. Sta. Rept. 18, p. 105 (1901); in Japanese. *Nectria coccophila* Nomura.

PARKIN, J.—Fungi parasitic on scale insects; a general account with special reference to Ceylon forms. Ann. Peradeniya, III, pp. 11–82 (March 1906).

PATOUILLARD, N.—[*Microcera Tonduzii* Pat.]. Bull. Soc. Myc. France, XXVIII, p. 142 (1912).

ROLFS, P. H.—A fungus disease of the San José scale. Florida Agric. Expt. Sta. Bull. 41 (1897). *Sphaerostilbe coccophila* Tul.

ROLFS, P. H. and FAWCETT, H. S. Fungus diseases of scale insects and white fly. Florida Agric. Expt. Sta. Bull. 94 (1908). *Sphaerostilbe coccophila* Tul.; *Ophionectria coccicola* E. and E.

SACCARDO, P. A.—Notae Mycologicae. Ann. Myc. VII (1909), p. 437. *Microcera curta* Sacc.

SAWADA, K. Some remarkable parasitic fungi on insects found in Japan (in Japanese). Botanical Magazine, Tokyo, XXVIII, p. 312 (1914). *Fusarium Aspidioti* Saw.

SEAVER, F.—Hypocreales of North America, II. Mycologia, I (1909), pp. 177–207. *Sphaerostilbe coccophila* Tul.; *Scoleconectria coccicola* (E. and E.).

SPEGAZZINI, C.—Fungi Guaranitici, Pugillus I. Anal. Soc. Cientif. Argentina, Buenos Aires, XVI–XXII (1883–1886). *Nectria coccorum* Speg.

—— —Fungi Puiggariani. Bolet. de la Acad. Nacional de Ciencias de Cordoba, XI (1889), p. 381. *Nectria coccogena* Speg.

STEVENSON, J. A.—Annual Report of the Insular Experiment Station of Porto Rico, 1917. *Tubercularia coccicola* Stev.

SYDOW, H. and P.—Novae fungorum species. Ann. Myc. XI (1913), p. 263. *Coccidophthora variabilis* Syd.

TULASNE, L. and C.—Selecta fungorum carpologia, I, p. 130 (1861); III, p. 99 (1865). *Sphaerostilbe*.

ZIMMERMANN, A.—Einige javanische, auf Cocciden parasitierende Ascomyceten. Centralb. f. Bakt., Abt. 2, VII, p. 872 (1901). *Nectria coccidophthora* Zimm.; *Lisea Parlatoriae* Zimm.; *Ophionectria coccicola* E. and E.; *Broomella Ichnaspidis* Zimm.

THE IMPERIAL BUREAU OF MYCOLOGY.

By E. J. Butler, C.I.E., D.Sc., M.B., F.L.S.

The movement which led to the establishment of the Imperial Bureau of Mycology originated from several different sources.

In the first place it had long been felt by many that the remarkable success that had attended the formation of the Imperial Bureau of Entomology, in encouraging and co-ordinating entomological work in relation to agriculture throughout the Empire was justification for the establishment of a similar organization to deal with the other great class of destructive agencies in agriculture, namely the diseases of plants caused by fungi. Then the shortage of supplies during the war emphasized the importance of conserving raw products obtained from the vegetable kingdom, for the provision of which this country is so dependent on the agricultural prosperity of the Overseas Empire. The bearing of economic mycology, especially plant pathology, in this matter was brought into prominence by a discussion at the Newcastle meeting of the British Association in 1916, at which specific proposals were made for the establishment of an Imperial Bureau of Mycology as a co-ordinating and stimulating agency for helping on the study of the diseases of plants throughout the Empire. At the same time some of the mycological workers in the overseas parts of the Empire began to press for improved facilities in England to replace the help in certain directions which they had been accustomed to obtain from foreign countries, some of which became enemy countries in 1914.

Thus the movement from within met with a similar movement from outside. The proposal to establish a Bureau of Mycology in London was laid before the Imperial War Conference in 1918, and, backed by the support of that powerful body, was referred to the Overseas Governments for consideration. The latter approved, and undertook to finance the Bureau for a period of three years in the first instance. On the initiative of the Colonial Office a Managing Committee was formed, comprising a number of well-known biologists with Viscount Harcourt as their Chairman, and the Bureau commenced work towards the end of last year. Quarters have been found for it in the former laboratory of the Plant Pests Branch of the Ministry of Agriculture at 17, Kew Green, as this Branch has been transferred to Harpenden. At Kew the Bureau has the advantage of proximity to the fine library and collections of the Royal

Botanic Gardens and it will work in close co-operation with the latter institution.

The following is a brief sketch of the proposed activities of the Bureau, which have been worked out in consultation with mycologists both here and in the colonies. As its primary function is to be of use to economic mycologists in the overseas parts of the Empire, the views of the latter have naturally great weight, and it is already evident that a great deal of consideration is being given by the Colonial Departments of Agriculture to the best methods of making the Bureau of real use. After having had nearly twenty years practical experience in India of the directions in which help is needed it was not difficult for me to suggest what the broad lines of our work should be; other useful proposals have been sent in from abroad, and there is no doubt that still more will follow.

There appear to be two main directions which must be followed if the Bureau is to justify its existence; and there are many subsidiary activities which will greatly add to its utility.

The two main directions are of equal importance. They are the accumulation and distribution of information on all matters connected with the diseases of plants, and the identification of specimens of injurious fungi.

For the former the Bureau must endeavour to keep in touch with mycological and pathological work going on in all parts of the world, and must index all the useful literature so that past and current work on any particular subject can be readily traced. The oversea worker is often in too isolated a position to be able to do this for himself: his first need is to know what has been done elsewhere on the problems with which he is faced and whether there is any recent or current work on them; and for this we hope to provide the necessary organization at the Bureau. The number of journals, periodical reports and the like that will have to be examined is very large, probably approaching four figures, but many of these have only an occasional reference of value. As soon as the necessary additional funds are provided (the original proposals in 1918 were calculated on a war basis) it is proposed to start a periodical abstracting journal on the lines of *The Review of Applied Entomology*, published by the Imperial Bureau of Entomology. But it is clear that this in itself will not be enough. We must be able to issue, on demand, the complete references to past work on the problems on which individual workers overseas are engaged. It will naturally take time before we can build up complete subject catalogues to enable this to be done readily. Besides the general subject catalogue we will require to compile, as soon as possible, a host-plant index, giving the fungi recorded on economically

important plants, for which the basis already exists in Vol. XIII and the subsequent volumes of Saccardo's *Sylloge Fungorum*, but which requires to be amplified in the direction followed in Oudemans' *Enumeratio Systematica Fungorum*. The latter only deals with the European flora, includes all plants, economic or not, and is of very limited value to, say, a worker in the tropics, as will be readily realized when we find only a single entry under the family *Zingiberaceae*, which includes such important crops as ginger and turmeric, both subject to several serious diseases. In addition to supplying references we must be prepared also to furnish abstracts and, in certain cases, to lend out original papers. This will be of great value to isolated workers and I attach great importance to it.

The next main line of work is to organize a system for the prompt identification of injurious fungi. In this respect mycologists have not at present as good facilities as those possessed by entomologists. Specialists in particular groups are not as readily available to us as to them; we are fewer in number and the amateur who specializes in a particular group is greatly to seek when once we descend below the higher fungi and enter the groups to which the majority of the injurious species belong. The organization here will have to be to some extent international as it is in entomology, and we must aim at being able to refer a species in a particular family or genus to the recognized authority on that group—when there is one. If, as I hope and expect, very large collections of fungi from the tropics and elsewhere are sent in, the Bureau can provide such material as to make it very attractive to systematic mycologists to specialize in certain families.

Arising out of this branch of the work is the comparative study of pathogenic fungi. This should be an important feature of the work of the Bureau and there is urgent need for the critical examination, with culture work, of such tropical pathogens as the *Phytophthoras*, *Diplodias*, *Glomerellas*, etc. When this work is under way there is no reason why it should not be developed into a culture-supplying organization, primarily to deal with tropical and sub-tropical forms. The chief difficulty in this is the want of suitable culture rooms at the Bureau, but a recent very helpful offer from the Lister Institute has suggested a way out.

Gradually there should be at the Bureau a very good herbarium of parasitic fungi. Such a collection will be essential for our own systematic work—for when all is said and done there will be a great deal of systematic work which the Bureau will have to undertake itself—and will be invaluable for reference purposes. Duplicates will be kept in as large quantities as

possible and named collections issued to various centres, especially the laboratories overseas. Types will not be kept at the Bureau as the collections there will be essentially working collections, the types being preserved at the Kew Gardens Herbarium or, in the case of specimens dealt with by outside specialists, at some centre agreed on in advance.

So far the Bureau has been considered as a centre for accumulating information and a clearing house for referring such information to the proper source, and as a centre for the systematic and cultural study of injurious fungi and an agency for getting the parasitic fungus flora of the overseas parts of the Empire worked out.

Nothing has been said about the prosecution of original research into the diseases of plants. The diseases with which we are concerned are those occurring in the distant parts of the Empire, and I hold strongly the view that true pathological research can only be done on the spot, where living clinical material is available. But I hope that the Bureau will become a place to which the overseas worker will naturally gravitate when in England on leave or otherwise, and every effort will be made to provide him with well-equipped laboratories where he can continue the study of problems in which he is interested, in directions which can be done at a distance from the crop concerned, and which can be checked and controlled by his own first-hand knowledge of the local conditions. I hope research work of various kinds will go on at the Bureau, but I hope equally that it will never be believed that the Bureau can replace the local worker, for that is not true.

Most countries now legislate for the exclusion or control of injurious fungi. Each country has usually worked out its own methods of dealing with this question and there is need for a central clearing house which can supply authentic information regarding the practice elsewhere. I am collecting the various acts and ordinances and I hope we will be able to notify changes or give other useful assistance in connexion with this matter.

It is often difficult for the isolated worker to procure the most suitable spraying or other appliances or to keep entirely up-to-date in the practical methods of dealing with fungus diseases. Here again I think we can usefully help by keeping in touch with manufacturers and with those who are testing new methods.

Apart from the diseases of plants, there are two other branches of applied mycology to which a brief allusion may be made, the study of the diseases of animals and man caused by fungi and the study of the fungi that are of importance in technical manufactures and trades. There is a vast field in our tropical

countries as yet almost unexplored (if we except the work of Castellani) in regard to the former of these subjects and I hope we can do something to stimulate research in it, and perhaps help in its more purely mycological side. Whether the Bureau can take any active part in the study of technically important fungi or not it is as yet difficult to say, but I have already had enquiries of this nature both in India and since I joined the Bureau, and I think there is a need in this direction also which we might do something to fill.

To sum up, it seems to me that the Bureau can be most usefully engaged if it has amongst its functions:

(1) The accumulation and distribution of information on all matters concerning the diseases of plants caused by fungi, of interest to workers in the overseas parts of the Empire.

(2) The publication of a periodical abstracting journal on the lines of *The Review of Applied Entomology*.

(3) The formation of a good reference library, especially of original papers in the reprint or "separate" form which will be available for issue on loan.

(4) The organization of a system for securing reasonably prompt identification of injurious fungi.

(5) The critical study of parasitic fungi which are at present the subject of confusion, such study to be in large part based on cultural methods; and the arrangement of facilities for the supply of authentically named cultures to overseas workers.

(6) The formation of a good working herbarium of parasitic fungi, with larger specimens and photographs illustrating diseases not known in this country; and the supply of named collections to other institutes and individuals.

(7) The provision of laboratory facilities to enable overseas workers to continue work, in problems in which they are interested, when in England.

(8) The organization of a central agency from which up-to-date information on such matters as legislation against plant diseases caused by fungi and recent progress in methods of control by spraying and the like can be supplied.

(9) The stimulation, as opportunity arises, of the study of other branches of applied mycology, such as those referred to above as being of interest in medicine and technology.

AN INVESTIGATION OF SOME TOMATO DISEASES.

By F. T. Brooks, M.A. and G. O. Searle, B.Sc.

In January 1913 a paper(2) was published by the senior author and another giving an account of a disease of tomatoes, isolated from the fruit and stems of plants grown out-of-doors.

This disease was identified by the late Mr Massee, as "*Ascochyta citrullina* C. O. Sm., the conidial form of *Mycosphaerella citrullina* Gross." which was also the name given by this authority(9) to the fungus causing an epidemic disease ("canker") of tomato stems in glass houses. In recent years this disease has been infrequent in English tomato houses, but it appeared in epidemic form in Holland during 1919 where it has been described by Schoevers(14) under the same name.

During the years 1911 to 1919 one of the writers collected various forms of fruit rots of tomatoes, and isolated the causal fungi. In August 1919 a detailed examination of these organisms was commenced and it seems desirable to place on record the results of this investigation obtained to date. During the early part of the joint investigation a few additional forms were collected by the junior author and included with the others.

Certain cultures and herbarium specimens were also obtained from various sources, and it will be convenient to tabulate here the origin of all the material used.

A. Phoma destructiva (Plowr.) C. O. Jamieson(7). This was an authentic culture obtained from the Department of Agriculture, Washington, D.C., in the summer of 1916 through the kindness of Dr C. L. Shear.

B. A culture of a pycnidial form of fungus from a rotten out-door tomato fruit collected at Merton, on September 17th, 1915.

C. A culture of a fungus showing both a pycnidial form of fructification and also spores of an *Alternaria* type on the same mycelium, obtained from a rotten tomato fruit collected at Bristol on January 25th, 1916. This fruit was one of a number purchased at a shop.

D. Colletotrichum phomoides (Sacc.) Chest. This was an authentic culture obtained from New York originally, but it was passed through tomato fruits and re-isolated in the autumn of 1915.

E. A culture of a pycnidial form of fungus from a rotten

tomato found lying on the ground at the Cambridge University farm on October 5th, 1916.

F. A culture of a pycnidial form of fungus from a tomato fruit, partly green, partly rotten, found at the same time and place as *E*.

G. A culture of a pycnidial form of fungus from a half-rotten tomato fruit collected at the same place and time as *E* and *F*, and only differing from them in that no pycnidia developed until it had been kept for some days in the laboratory. This culture was found to produce pycnidia and spores very sparingly and was later discarded as it was not found possible to obtain a single-spore culture from it. In the preliminary examination no difference from *E* and *F* could be detected, except that the spores were generally slightly smaller.

H. A culture of a pycnidial form of fungus from a rotten tomato (one of seven) collected in a garden at Cambridge, November 2nd, 1916.

I. This form was discarded.

J. A culture of a pycnidial form of fungus from a rotten half-ripe tomato collected at Cambridge, September 1918.

K. A culture of a *Glocosporium* or *Colletotrichum* from a rotten half-ripe tomato collected at Cambridge, September 1918.

K 2. A culture of a *Glocosporium* or *Colletotrichum* which appeared in the laboratory on an apparently sound ripe tomato, which had been inoculated with "A" in October 1919.

L. A culture of a pycnidial form of fungus from a diseased tomato bought in the market at Cambridge on January 17th, 1919.

M. A culture of a pycnidial form of fungus from a shrivelled tomato collected out-of-doors at Cambridge, March 1919.

N. A culture of a *Fusarium* from a rotten tomato collected at Longstowe, Cambridgeshire, August 1919.

O. This was discarded.

P. A culture of a pycnidial form of fungus from a sun-cracked tomato collected out-of-doors at Longstowe, October 1919.

Q. A culture of a pycnidial form of fungus from a rotten tomato collected out-of-doors at Longstowe, October 1919.

R. This was discarded.

S. A culture of a *Colletotrichum* from a rotten tomato collected at Cambridge, December 1919.

T. *Ascochyta Pisi* Lib. A culture from the Centralstelle für Pilzkulturen, Amsterdam.

U. *Mycosphaerella citrullina* (C. O. Sm.) Gross. An authentic culture kindly furnished by Dr C. L. Shear of the United States Department of Agriculture in the autumn of 1919. This was

originally collected at Detroit, Michigan from a cucumber grown in Florida. To date no fructifications have formed on any of the media used so that it has not been possible to make a single-spore culture.

The herbarium specimens examined for the purpose of this investigation were as follows:

1. *Mycosphaerella citrullina* on tomato stem collected at Cheshunt, June 1st, 1911, kindly supplied by Mr A. D. Cotton, Ministry of Agriculture, Herbarium No. A 14405.

2. *Mycosphaerella citrullina* on tomato stem collected at Finchley, July 1915. From the same source as No. 1, Herbarium No. A 25208.

3. *Mycosphaerella citrullina* (C. O. Sm.) Gross. on watermelon stem, collected at Lakeland, Fla., U.S.A., in April 1919, kindly sent by Dr C. L. Shear.

4. *Mycosphaerella citrullina* (C. O. Sm.) Gross. on watermelon from Florida, collected in New York market, May 1919; also sent by Dr C. L. Shear.

5. *Mycosphaerella citrullina* Gross. on tomato stem collected by A. A. Wills at Cheshunt, September 16th, 1910; in the Kew herbarium(6).

6. *Mycosphaerella citrullina* Gross. on tomato stem collected by F. Hearnum at Waltham Cross on June 14th, 1909; in the Kew Herbarium.

7. *Mycosphaerella citrullina* Gross. on the lower part of melon stem, collected by I. W. Read at Norwich, September 1912; in the Kew Herbarium.

8. *Phoma Lycopersici* Cke. on tomato stem. Collected by J. E. Vize (*circa* 1884?); in the Kew Herbarium.

9. *Diplodina citrullina* (Sm.) Gross. Collected in Brandenburg "auf trockenen Ranken von *Cucumis sativus*" by P. Vogel, December 18th, 1908; from Sydow's "Mycotheca germanica"; in the Herbarium of the British Museum.

10. *Mycosphaerella citrullina* (C. O. Sm.) Gross. on cucumber fruit collected in Florida, May 1917. Received from Dr C. L. Shear(5).

An effort was also made to obtain Plowright's type specimens of *Phoma destructiva* and *Sphaeronema Lycopersici*(9) but these were not forthcoming*.

A detailed investigation of the cultural and other characteristics of the various forms isolated was commenced in August 1919. In the preliminary cultural trials "pure cultures" were used but not "single-spore" cultures; single-spore cultures were

* We are indebted to Mr W. B. Grove for kindly searching for these specimens in Plowright's herbarium, which is now in the Botanical Department of Birmingham University.

isolated later and were used throughout the remainder of the investigation. The cultures and inoculations were made and maintained at ordinary laboratory temperatures.

PRELIMINARY INOCULATIONS AND CULTURE EXPERIMENTS.

A preliminary series of inoculations and culture experiments were carried out, using the various forms as isolated on tomato agar. Twelve forms were used, namely: *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, *J*, *K*, *L*, *M*, which were the only ones available at the time. The following hosts and artificial media were employed with a view to obtaining a general idea of the characteristics of the various forms and to discover, if possible, some medium which would give a maximum spore formation, before proceeding to the isolation of single-spore cultures and a final comparison of the various forms.

Series A consisted of inoculations into nearly ripe tomato fruits kept in a large glass dish in the laboratory. Two cuts were made with a sterile scalpel in each fruit and a fragment of mycelium introduced from each culture. Control tomato fruits were cut but not inoculated.

In each case a rot of the fruit commenced by the fourth day, except in the controls which remained healthy. All the forms were then successfully re-isolated on to tomato agar from the fruits. Descriptions of the appearance of these fungi on tomato fruits are given later.

Series E consisted of inoculations of pieces of petiole of vegetable marrow, sterilised and kept in tubes at laboratory temperature. On this substratum all the various forms grew luxuriantly and spores were freely produced.

Series G consisted of inoculations into stems of living tomato plants in a greenhouse. Mycelium was inserted into a slit in the stem and the wound was then bound up with tin-foil. In the case of Form *L* a large canker was formed about 2½ inches long, which spread also to the base of adjacent branches. Large numbers of pycnidia were visible, and re-isolation on to tomato agar was carried out giving Form *L* again. In all the other inoculations there was a slight discoloration of the stem, but no cankers were formed nor was there any trace of pycnidia.

Series K consisted of inoculations on to sterilised potato cores, *Series L* on to sterilised potato cores plus 1 % glycerine, and *Series M* on to potato agar; these three media were used to try to discover one which would give a uniform production of fruiting bodies of the various forms. However, none of them was particularly successful, though all the various forms developed on these media to a greater or less extent as far as the

mycelial stage was concerned. The mycelium was more scanty on potato agar than on the other two media.

Series N was undertaken to test the pathogenicity of these twelve forms on the fruit of the vegetable marrow. A large fruit was selected and vertical slits about one inch apart were made round the circumference, into which the various forms were inoculated. In no case did a positive infection occur.

A few other preliminary experiments were made and will be briefly mentioned here.

Inoculations with forms *C*, *J*, and *M* were made into pears under bell jars in the laboratory, pears with sterile cuts and tomato fruits with inoculations of *C*, *J* and *M* being used as controls. Typical rots with abundant pycnidia were formed on the control tomato fruits, but in the pears no rot was caused by Form *C*, whilst Forms *J* and *M* both formed large soft brown rots although no mycelium nor pycnidia showed on the surface.

Preliminary experiments were then tried for the purpose of indicating whether the various forms were wound or non-wound parasites of tomato fruits. It was found that the finest prick on the surface was sufficient to allow the entry of the fungus when spores were sown on the surface, but infection never resulted when spores were sown on the uninjured surface, even when spores were sown in a drop of 10 % sugar solution to assist germination or when mycelium was placed on the surface of the fruit in a fragment of tomato agar.

Spore suspensions of Forms *C* and *H* were sprayed over tomato plants about two feet high in the greenhouse, but no infection nor leaf spotting took place.

ISOLATION OF SINGLE-SPORE CULTURES AND EXPERIMENTS THEREWITH.

During October, November, and December 1919, single-spore cultures of all the forms were made. Each form was passed through the tomato fruit and back on to tomato agar, single-spore cultures being established on the latter by the dilution method. As soon as single-spore cultures of all the forms had been obtained, the following fourteen series of inoculations and culture experiments were carried out to obtain some idea of the characters of the various forms on different media with a view to their systematic arrangement.

All the forms were not used in every series, sometimes owing to lack of material. The following table shows in brief the results of these experiments.

Table I. *Cultures on tomato agar were always used.*

Host or medium used	Forms used	Results
(1) Sterilised tomato stems in tubes	All except *G*, *S* and *U*	Very profuse growth of mycelium in all; fruiting bodies generally formed
(2) Tomato plants; needle pricks made in stem	*B*, *C*, *D*, *E*, *H*, *K*2, *L* and *T*	Only *L* took; canker encircled the stem which collapsed; pycnidia formed
(3) Potato agar	All except *G*, *S* and *U*	Mycelium scanty. Fruiting bodies usually formed sparingly
(4) Melon plants in greenhouse. Needle pricks made in stem	*B*, *D*, *K*2, *L*, *T*	No infection
(5) Cucumber plants in greenhouse. Needle pricks made in stem	*B*, *L*, *T*	No infection
(6) Carrots in the laboratory. Needle prick inoculations	*A*, *B*, *D*, *J*	No infection
(7) Apples (Cox's Orange) in the laboratory. Needle prick inoculations	*B*, *J*, *L*	No infection
(8) Potatoes in the laboratory. Needle prick inoculations	*C*, *E*, *J*, *L*	*L* formed a dry sunken canker with typical pycnidia and spores. *C*, *E*, *J* without effect
(9) Sterilised potato cores	All except *G*, *S* and *U*	Generally a profuse growth of mycelium with a fair number of fruiting bodies
(10) Green grapes kept in an incubator at 27° C. Needle prick inoculations	All except *G* and *S*	No infection
(11) Dox's medium (5) (30 grms. cane sugar per litre)	All except *G*, *S* and *U*	Mycelium generally profuse and dark coloured, quite obscuring the fruit bodies
(12) Dox's medium (15 grms. cane sugar per litre)	All except *G*	Mycelium less profuse, lighter colour, fruiting bodies plentiful
(13) Dox's medium (7·5 grms. cane sugar per litre)	All except *G*	Mycelium less profuse, fruiting bodies plentiful
(14) Green tomato fruits in the laboratory. Needle prick inoculations	All except *G* and *S*	All formed typical rots except *U*

In the course of these experiments it was soon found that these forms of fungi took on great differences in growth-characteristics according to the medium used; with the exception of type *C* it was impossible to pick out these forms by any feature which was constant throughout all the media and hosts tried.

The conclusion was reached that it was absolutely necessary to use a purely artificial medium like Dox's, if any attempt was to be made to put on record differences between such closely related species or varieties as were being used, which would have value for other workers.

In using Dox's medium it was found that the normal amount of cane sugar, *i.e.* 30 grms. per litre, produced a too profuse mycelial growth, so that fruit bodies, specially of the pycnidial type, were obscured and such details as the colour of the spore mass could not be determined.

The amount of sugar was therefore first modified to 15 grms. per litre and later to 7·5 grms. per litre. This latter medium appeared to give the most satisfactory results.

On duplicating the whole series on the medium containing 7·5 grms. sugar no appreciable difference could be discerned between the two tubes of each form, an effect which was not seen when working with other media such as tomato agar.

The formula used in this modification of Dox's medium was as follows:

Magnesium sulphate	0·5 grm.
Potassium acid phosphate ...	1·0 ,,
Potassium chloride	0·5 ,,
Ferrous sulphate	·0·01 ,,
Sodium nitrate	2·0 grms.
Cane sugar	7·5 ,,

Made up to 1000 c.c. with 2 % agar.
The acidity was + 13·6.

DESCRIPTION OF THE MACROSCOPIC CHARACTERS OF THE VARIOUS FORMS ON TOMATO FRUITS.

The following gives the appearance of these fungi on tomato fruits about ten days after inoculation:

Form A. A black spot roughly circular about ½–1 inch in diameter, slightly sunken towards the circumference, generally raised in the centre at the point of inoculation. Shades off in colour towards the uninjured part of the fruit. Very numerous black pycnidia aggregated round the centre and erumpent through the epidermis of the fruit, giving the surface a roughly punctate, carbonaceous appearance.

Form B. Large brown spot, with numerous brown pycnidia erumpent through the epidermis of the fruit.

Form C. Large brownish black spot, about one inch in diameter, raised in the centre and sunken towards the circumference. Very numerous, densely gregarious pycnidia, varying from brown to black in colour, covered with dull greyish pink, slimy, spore masses.

Form D. Watery-looking, rugged canker about one inch in diameter, entirely covered with closely aggregated black acervuli, surrounded by a circle of younger acervuli covered with pink spores.

Form E. Large, light brown spot, not raised nor depressed, numerous light brown pycnidia.

Form F. Same appearance as *E* but the pycnidia of a somewhat darker brown.

Form H. Same appearance as *F.*

Form J. Large, brownish spot, rather sunken below the remainder of the surface, numerous pycnidia varying from brown to black.

Form K. Large, rather watery-looking spot, completely covered with pink cushions of spores, later becoming blackish.

Form K 2. Similar to *K*, but later the pink cushions (acervuli) became black and the appearance was then similar to *D.*

Form L. Large canker covered with black pycnidia.

Form M. Large, rugged, brown canker covered with brown pycnidia.

Form N. Large canker covered with white mycelium and masses of pink *Fusarium* spores.

Form P. Large brown cankered spot, rather rugged surface, covered with brown pycnidia.

Form Q. Smooth, black spot, almost shiny surface, numerous pycnidia scarcely erumpent through the epidermis of the fruit.

Form S. Black acervuli formed with typical, pointed setae and large numbers of spores.

Form T. Large spot about 1½ inches in diameter, self coloured, not soft, no visible pycnidia but very numerous pink tendrils of spores projecting through the surface from pycnidia evidently subcutaneous.

Form U. The fungus spread only to a very slight extent when inserted into tomato fruits, and no fructifications were formed.

It would make this paper of undue length to include a full macroscopic description of these forms on all the different media used. For one thing, the composition of such media as tomato agar and potato agar varies considerably in different batches, and undoubtedly the macroscopic characters of the cultures vary with changes in the medium, so that the characters shown on a medium such as tomato agar or potato agar would probably not be of great value to other investigators. In the following description, therefore, only the microscopic characters on the third modification of Dox's medium, i.e. the one containing 7·5 grms. cane sugar per litre, are given, with occasional notes on special points shown on other media, since Dox's medium, being of a synthetic nature, can be duplicated at will with the knowledge that future batches will be of very close comparative chemical composition with the medium from which the present diagnoses were made.

MACROSCOPIC CHARACTERS OF THE VARIOUS FORMS ON DOX'S MEDIUM MODIFIED TO CONTAIN 7·5 GRMS. CANE SUGAR PER LITRE, WITH OCCASIONAL NOTES ON CHARACTERISTICS SHOWN BY THE FORMS ON OTHER MEDIA.

Form A. Aerial mycelium fairly plentiful, varying from white to grey. Medium not coloured, submerged mycelium hyaline. Pycnidia very numerous, black, small, more closely aggregated towards the middle of the culture, semi-erumpent. No visible spore mass. This form generally produced pycnidia very sparingly. The quantity of mycelium varied greatly on different media; on potato agar it was very slight with a few light brown pycnidia, whilst on Dox's medium with 30 grms. sugar per litre, the mycelium was very profuse and dark olive green in colour.

Form B. Aerial mycelium fairly plentiful, generally white but varying to light grey in colour, submerged mycelium hyaline. Pycnidia numerous, scattered, varying greatly in size, generally in the aerial mycelium, sometimes on the surface of the medium, black in colour. With potato agar, on the other hand, the mycelium was dark coloured and largely submerged in the medium, and numerous dark coloured appressoria were formed towards the edge of the culture; on tomato agar a dirty yellow-coloured spore mass was noticeable and on Dox's medium with 30 grms. sugar the mycelium was very profuse and almost black.

Form C. Aerial mycelium very slight, fulvous brown to grey. Pycnidia very numerous, chocolate brown in colour with a few pink spore masses. Pycnidia apparently seated on the surface of the medium. On Dox's medium with 15 grms. sugar per litre, the spore masses were very conspicuous as pink spots which coalesced all over the surface of the medium, whilst at the top and bottom of the culture were dark brown bands of aerial mycelium bearing the *Alternaria* form of spores; on potato agar, on the other hand, both mycelium and pycnidia were scanty, the latter being light brown in colour and almost entirely aggregated along the original inoculation streak. All the cultures were similar in showing scanty mycelial growth and early formation of pycnidia, the first being usually formed within 48 hours of the culture being made. The *Alternaria* form invariably appeared later and upon the drier portion of the culture. Sowings of the *Alternaria* spores were made and these produced pycnidia first and *Alternaria* later. Cultures made from single pycnospores also formed spores of *Alternaria* as well as pycnidia.

Form D. Aerial mycelium grey, tending to become matted.

Pink tinge at the surface of the medium. Submerged mycelium slight and hyaline. Black acervuli large and scattered, with numerous smaller black bodies, apparently sterile acervuli, which were scattered throughout the medium. On other media the cultures only differed in the numbers of acervuli.

Form E. Aerial mycelium very scanty, white; submerged mycelium hyaline, scanty; pycnidia and spore masses very numerous and both of a light brown or straw colour. Other cultures showed variations in the colour of the mycelium, but the pycnidia were always light brown in colour.

Form F. Aerial mycelium fairly plentiful, white, tending to be floccose. Pycnidia very numerous, light brown, particularly aggregated at the bottom of the culture. Spore masses infrequent, light yellowish brown in colour. In this case, the colour of the pycnidia varied greatly, as on tomato agar and sterilised tomato stem the pycnidia were almost black; this was not a matter of age of culture since, on Dox's medium, the pycnidia were still light brown in colour at the end of eight months.

Form H. Aerial mycelium, white, scanty at the top of the culture but denser at the base. Pycnidia numerous, dark brown, mainly aggregated at base of culture, on surface of medium or in aerial mycelium, larger than in *E* and *F*. Spore masses few and light brown. Fairly similar characteristics were shown on the other media, the mycelium varying, however, from white to dark grey.

Form J. Aerial mycelium plentiful, white. Pycnidia few, large, brown, tending to be confluent; spore masses light brown to yellow. Pycnidia partly submerged in the medium. Generally, only few pycnidia were formed, except on potato cores and tomato stems, on which the number was large and their colour black.

Form K. Aerial mycelium plentiful, white to dark brown-grey. Large aggregations of very dark-coloured submerged mycelium. No trace of fructifications. This form produced very few spores and in artificial cultures spores appeared only early in the development of the fungus and not on a distinct acervulus—at least no black acervuli were visible as in Form *D*; on tomato fruits the spores were aggregated on acervuli and were numerous, but the same dense cushion of mycelium covered with spores was not observed in any culture.

Form K 2. This culture was similar to *K*, except that the mycelium was more scanty. Here again no proper acervuli were formed in culture except in one on tomato agar where a few black acervuli were visible. The sporing stage, as in *K*, could be seen from the pink tinge taken on by the mycelium in the early stages.

Form L. Aerial mycelium, white, scanty, evanescent, adpressed to the medium. Pycnidia exceedingly numerous, brown, with light brown spore masses, generally half-submerged in the medium, some wholly submerged. This was a very constant form on all media, always showing very scanty mycelium and exceedingly numerous brown pycnidia.

Form M. Aerial mycelium plentiful, tending to be matted, greyish white. Pycnidia fairly numerous, scattered at the top of the culture and aggregated towards the bottom, brown to light brown in colour, with yellow brown spore masses. On other media the production of pycnidia was slight except on sterilised tomato stems, where they were very numerous and black in colour.

Form N. Aerial mycelium very scanty, evanescent, white. Large, confluent, salmon pink spore masses. Mycelium was always rather scanty except on potato cores and sterilised tomato stems, but the cultures were very distinct by reason of the large confluent masses of *Fusarium* spores.

Form P. Aerial mycelium very profuse, white, matted. Pycnidia very few, scattered, brown, large. On different media the pycnidia varied from brown to black.

Form Q. Aerial mycelium fairly plentiful, white, closely adpressed to the medium. Pycnidia very few, brown. Spore formation very sparse on all media.

Form S. Aerial mycelium very scanty and almost entirely evanescent. Acervuli very numerous, black, scattered all over the culture. In earlier stages the medium took on a pinkish tinge.

Form T. Aerial mycelium very scanty and evanescent, white. Pycnidia numerous, yellowish brown, later a red brown, entirely covered with profuse, pink spore masses. The colour of the pycnidia and spore masses varied considerably on various media; pycnidia dark brown on potato agar, light brown on tomato agar; spore masses dirty pink to salmon colour on tomato agar, brick red on potato cores.

Form U. Aerial mycelium profuse, grey, adpressed to the medium. No fructifications were produced by this form on any medium, which was disappointing as it was the only culture of an authentic *Mycosphaeralla citrullina* and so was important for comparative purposes.

Before discussing the microscopic characters of the various forms and comparing them with the herbarium and other material obtained, it will be convenient to divide them into groups.

The first and most important section, Group *A*, contains all the forms having a pycnidial type of fructification and probably belonging either to the genus *Phoma* or to the genus *Diplodina*.

This GROUP *A* includes the following forms:

Form A: which is an authentic specimen of *Phoma destructiva* (Plowr.) C. O. Jamieson, from America.

Form B.

Form C: which possesses an *Alternaria* form of spore as well as a pycnidial stage.

Forms E, F, H, J.

Form L: which is pycnidial but shows differences from the other forms in its wider infective powers and greater percentage of septate spores.

Forms M, P, Q.

Form T: which is a specimen of *Ascochyta Pisi* Lib.

Form U: no fructifications were formed by this.

GROUP *B* consists of those forms which can be placed either in the genus *Colletotrichum* or *Gloeosporium*, and includes:

Form D: which is an authentic culture of *Colletotrichum phomoides* (Sacc.) Chester from America.

Forms K, K 2 and *S.*

GROUP *C* consists only of Form *N* which is a typical species of the genus *Fusarium.*

In studying the various forms of Group *A* it was found that these showed great variability in characters which are generally looked upon as specific, such as size of spores, septation of spores, guttulation and shape of spores, and one was forced to the conclusion that a number of so-called species in genera like *Phoma*, *Ascochyta* and *Diplodina*, are nothing more than varieties of one and the same fungus. In fact, it is difficult to see how a final decision is to be made in many cases unless the investigator has the opportunity of carrying out a large number of cultural trials on artificial media and also cross inoculations on to various hosts. A comparison of the microscopic characters found in the pycnidial forms included under Group *A* will now be made:

MICROSCOPIC CHARACTERISTICS OF THE VARIOUS FORMS INCLUDED IN GROUP *A* (PYCNIDIAL FORMS) ON TOMATO FRUITS AND CULTURE MEDIA.

Form A.

	Description given by Miss Jamieson (q.v.)	Description of authors' cultures
PYCNIDIA.	Scattered to aggregate, most abundant towards centre of spot, subcutaneous later erumpent, glabrous, brownish black, subglobose, slightly papillate,	Pycnidia varying greatly in size, sometimes single, sometimes compound with two or more ostioles (sometimes as many as four). Pycnidia

	Description given by Miss Jamieson (q.v.)	Description of authors' cultures
	not beaked, ostiolate (usually one sometimes two pores), 30–350 μ in diameter. Pycnidial wall thin, outer cells brown, inner cells hyaline; delicate filiform basidia arising from inner cells.	usually globose but irregular shapes seen, light yellowish brown, ostiole surrounded by a dark circle. Erumpent through the epidermis.
PYCNOSPORES.	Issue in coils through ostiolum forming a shiny flesh-coloured exudate...hyaline.	Issue in coils through the ostiolum. Hyaline.
SHAPE.	Sub-cylindrical to sub-globose, rarely tapering.	Sub-cylindrical with rounded ends, occasionally slightly asymmetrical.
SEPTATION.	Continuous.	Non-septate.
GUTTULATION.	2-guttulate.	Rarely faintly biguttulate.
SIZE.	2·8 μ–8·5 μ × 1·7 μ–3·4 μ.	3·5 μ–5·5 μ × 2 μ–3 μ. Very uniform in size.

Form B.

PYCNIDIA.	Pycnidial characters as to shape, size and colour varied so much as to seem unreliable for diagnostic purposes and are omitted in this and other forms.
PYCNOSPORES.	Issue in coils through the ostiolum. Hyaline.
SHAPE.	Ovate, usually slightly asymmetrical on one side and often slightly pointed at one end.
SEPTATION.	Non-septate.
GUTTULATION.	Bi-guttulate.
SIZE.	3·5 μ–7·5 μ × 2 μ–3·5 μ (20 measurements). Dark, thick-walled appressoria were also formed.

Form C.

PYCNOSPORES.	Issue in coils through ostiolum. Hyaline.
SHAPE.	Ovate with a tendency to pointed ends.
SEPTATION.	Non-septate.
GUTTULATION.	Very faintly biguttulate, except on Dox's medium, where they were strongly biguttulate and the average size was larger.
SIZE.	3 μ–7·5 μ × 2 μ–3·5 μ (20 measurements). An *Alternaria* form of spore was borne on the same mycelium, a large brown-coloured multi-septate spore of greatly varying shape and size. There were also numerous, thick-walled, dark coloured spore-like bodies averaging 8 μ × 4 μ round the edges of the cultures; these were not observed to germinate or become detached from the mycelium and they were taken to be a kind of appressorium formed under cultural conditions.

Form E.

PYCNOSPORES.	Issue in coils through ostiolum. Hyaline.
SHAPE.	Irregular, usually ovate to cylindrical, usually with rounded ends, but sometimes one end pointed, occasionally slightly curved.

Septation.	Usually non-septate, but about 10–20 % 1-septate, generally slightly constricted at the septum.
Guttulation.	Very rarely bi-guttulate.
Size.	3·5 μ–9 μ × 2 μ–3·5 μ non-septate. 7·5 μ–11 μ × 3 μ–3·5 μ 1-septate (20 measurements).

Form F.

Pycnospores.	Issue in coils through ostiolum. Hyaline.
Shape.	Ovate to cylindrical with rounded ends, occasionally slightly curved.
Septation.	Usually non-septate, but 5 % of the spores from a tomato agar culture were 1-septate, and on Dox's medium between 5 % and 10 % were 1-septate. Septate spores scarcely, if at all, constricted at the septum. In this form a spore mass which had been extruded some time from a pycnidium showed up to 50 % of the spores septate.
Guttulation.	About 40 % of the spores were bi-guttulate.
Size.	4 μ–8·5 μ × 2·5 μ–4 μ non-septate. 7 μ–9 μ × 3 μ–3·5 μ 1-septate (20 measurements).

Form G.

Discarded.

Form H.

Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Ovate to sub-cylindrical, all very uniform in shape and size.
Septation.	Non-septate.
Guttulation.	Bi-guttulate.
Size.	3·5 μ–6·5 μ × 2·5 μ–3·5 μ (20 measurements).

Form J.

Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Ovate to cylindrical with rounded ends, occasionally slightly curved.
Septation.	Usually non-septate, about 5–10 % 1-septate, scarcely, if at all, constricted at the septum. Spores from a spore mass on Dox's medium were about 30 % 1-septate.
Guttulation.	Occasionally faintly bi-guttulate.
Size.	3·5 μ–9 μ × 2·5 μ–3·5 μ non-septate. 8 μ–10·5 μ × 3 μ–4 μ 1-septate (20 measurements).

Form L.

Pycnidia.	Sometimes malformed and assuming a tubular form a millimetre or more long in culture. Frequently with more than one ostiole.
Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Cylindrical, rounded ends, some slightly curved, some ovate. Sizes varying considerably.
Septation.	About 40 % 1-septate, the remainder non-septate. Always constricted at the septum. On potato agar up to 80 % 1-septate.
Guttulation.	Occasionally bi-guttulate.
Size.	4·5 μ–11 μ × 2·5 μ–5 μ non-septate. 7·5 μ–12·5 μ × 3·5 μ–4·5 μ 1-septate (20 measurements).

Form M.

PYCNOSPORES.	Issue in coils through ostiolum, hyaline.
SHAPE.	Ovate to sub-cylindrical, rounded ends, very varied in size and shape.
SEPTATION.	Usually non-septate, about 20 % 1-septate and generally constricted at the septum. Occasionally 2-septate.
GUTTULATION.	No guttules.
SIZE.	4·5 μ–12 μ × 2 μ–4 μ non-septate. 9 μ–17 μ × 2·5 μ–5 μ 1-septate. 15 μ × 3·5 μ (20 measurements).

Form P.

PYCNOSPORES.	Issue in coils through ostiolum, hyaline.
SHAPE.	Ovate to sub-cylindrical with rounded ends, occasionally slightly curved.
SEPTATION.	Usually non-septate, about 10 % 1-septate, not constricted at the septum. Percentage of septate spores rapidly increases with age.
GUTTULATION.	Very occasionally a single guttule.
SIZE.	3·5 μ–10 μ × 2 μ–4 μ non-septate. 8 μ–14 μ × 3 μ–4 μ 1-septate (20 measurements).

Form Q.

PYCNOSPORES.	Issue in coils through ostiolum, hyaline.
SHAPE.	Ovate to cylindrical, one end usually and sometimes both ends pointed.
SEPTATION.	Non-septate.
GUTTULATION.	Generally bi-guttulate.
SIZE.	4 μ–8 μ × 2·5 μ–3·5 μ (20 measurements).

Form T.

This was a specimen of *Ascochyta Pisi* Lib.

PYCNOSPORES.	Issue in coils through ostiolum, the coil often attaining a length of two or three millimetres. Hyaline, often very vacuolate, but non-vacuolate in perfectly fresh spores.
SHAPE.	Cylindrical with rounded ends, often slightly curved.
SEPTATION.	95 % 1-septate, occasionally 2 or 3-septate, not constricted at the septum, except in perfectly fresh spores which were slightly constricted.
GUTTULATION.	Indefinite.
SIZE.	10·5 μ–17·5 μ × 2·5 μ–4·5 μ 1-septate. 14·5 μ × 3·5 μ 2-septate. 24 μ × 4·5 μ 3-septate. 8 μ × 3 μ non-septate (20 measurements).

The systematic position of species of the genera *Phoma*, *Ascochyta*, and *Diplodina* is difficult to determine.

The chief difference between the genera *Phoma* and *Diplodina* is that, according to systematists, the spores of *Phoma* are non-septate and those of *Diplodina* 1-septate.

A study of the herbarium specimens does not tend to make matters easier as will be seen by the following descriptions:

Herbarium Specimen 1. MYCOSPHAERELLA CITRULLINA (reputed) on tomato stem, England (only pycnidial stage present).

PYCNOSPORES. Ejected in coils from ostiolum. Spores rather shrunken and mis-shapen through age.

SHAPE. Very irregular.

SEPTATION. Usually non-septate, about 20 % 1-septate: usually constricted at the septum.

GUTTULATION. About 50 % bi-guttulate.

SIZE. 5 μ–11 $\mu \times 3$ μ–4 μ non-septate. 9 μ–10·5 $\mu \times 3$ μ–4 μ 1-septate.

Herbarium Specimen 2. MYCOSPHAERELLA CITRULLINA (reputed) as No. 1 (only pycnidial stage present).

PYCNOSPORES. Ejected in coils from ostiolum. Hyaline.

SHAPE. Irregular, often constricted at the centre, some slightly curved, some pear-shaped.

SEPTATION. Usually non-septate, only about 5 % 1-septate.

GUTTULATION. Occasionally indistinctly bi-guttulate.

SIZE. 4 μ–10 $\mu \times 2{\cdot}5$ μ–3·5 μ non-septate. 8 μ–10·5 $\mu \times 3{\cdot}5$ μ 1-septate.

Herbarium Specimen 3. MYCOSPHAERELLA CITRULLINA (C. O. Sm.) Gross., on water-melon stem (pycnidial stage) from America.

PYCNOSPORES. Ejected in coils through the ostiolum, the pore of the ostiolum seemed narrower than usual and the spores were ejected in a coil only three or four spores wide. Spores hyaline.

SHAPE. Very regular, cylindrical, rounded at the ends, very rarely slightly curved.

SEPTATION. Usually non-septate, rarely faintly 1-septate (about 10 %).

GUTTULATION. Indefinite.

SIZE. 5 μ–14 $\mu \times 2{\cdot}5$ μ–5 μ non-septate. 10 μ–13 $\mu \times 3{\cdot}5$ μ–4 μ 1-septate.

Herbarium Specimen 4. MYCOSPHAERELLA CITRULLINA (C. O. Sm.) Gross., on water-melon, same source as No. 3 (pycnidial stage).

PYCNOSPORES. Ejected in coils through ostiolum, hyaline.

SHAPE. Cylindrical, rounded ends, sometimes slightly curved.

SEPTATION. Always 1-septate, occasionally 2-septate.

GUTTULATION. Generally bi-guttulate.

SIZE. 10·5 μ–17 $\mu \times 3$–3·5 μ 1-septate. 14 μ–15 $\mu \times 3{\cdot}5$ μ–4 μ 2-septate.

Herbarium Specimen 5. MYCOSPHAERELLA CITRULLINA Gross. (reputed), on tomato stem, England; in the Kew Herbarium (pycnidial stage only).

PYCNOSPORES. Ejected in coils through the ostiolum, hyaline.

SHAPE. Cylindrical, rounded ends, regular. Some very slightly curved.

SEPTATION. Usually non-septate, about 20 % 1-septate, not constricted at the septum.

GUTTULATION. No guttules.

SIZE. 4 μ–10 $\mu \times 2{\cdot}5$ μ–3·5 μ non-septate. 8·5 μ–10 $\mu \times 3$ μ–3·5 μ 1-septate.

Herbarium Specimen 6. MYCOSPHAERELLA CITRULLINA (reputed), on tomato stem, England; in the Kew Herbarium (pycnidial stage only).

PYCNOSPORES.	Ejected in coils through the ostiolum, hyaline.
SHAPE.	Mainly cylindrical with rounded ends, but irregularly shaped and curved, spores numerous.
SEPTATION.	About 60 % 1-septate, sometimes slightly constricted at the septum.
GUTTULATION.	Few spores bi-guttulate, a few one-guttulate.
SIZE.	6 μ–10 μ × 2·5 μ–4 μ non-septate. 7·5 μ–11 μ × 3 μ–4 μ 1-septate.

Herbarium Specimen 7. MYCOSPHAERELLA CITRULLINA (reputed), on lower part of melon stem, England, in the Kew Herbarium (pycnidial stage only).

PYCNOSPORES.	Very few spores were obtained from this specimen and the mode of ejection from the pycnidium could not be determined.
SHAPE.	Cylindrical with rounded ends.
SEPTATION.	All except 3 spores (15 was total number seen) were very faintly 1-septate, no constriction at septum.
GUTTULATION.	No guttules.
SIZE.	8 μ–10 μ × 2·5 μ–3·5 μ 1-septate. 7 μ–9 μ × 3 μ non-septate.

Herbarium Specimen 8. PHOMA LYCOPERSICI Cke., on tomato stem, England. This was Cooke's type specimen in the Kew Herbarium.

PYCNIDIA.	Pycnidia brown, roughly spherical to triangular, average diameter 170 μ. Ostioles usually 1, sometimes more. A few compound pycnidia seen. Only a few spores were obtained.
PYCNOSPORES.	Hyaline, but the mode of ejection from the pycnidium could not be determined.
SHAPE.	Cylindrical with rounded ends, very regular.
SEPTATION.	90 % 1-septate.
GUTTULATION.	No guttules.
SIZE.	8 μ–12 μ × 2·5 μ–4 μ 1-septate. 7 μ–11 μ × 2·5 μ–3·5 μ non-septate (20 measurements).

Herbarium Specimen 9. DIPLODINA CITRULLINA (reputed), on dried stems of cucumber, from Germany, 1908; in the Herbarium of the British Museum.

PYCNIDIA.	Pycnidia light brown with a darker band surrounding the lighter-coloured ostiole.
PYCNOSPORES.	Hyaline, but the mode of ejection from the pycnidium could not be determined.
SHAPE.	Not cylindrical.
SEPTATION.	About 40 % 1-septate.
GUTTULATION.	No guttules.
SIZE.	5–9 μ × 2·5 μ–3·5 μ.

Herbarium Specimen 10. MYCOSPHAERELLA CITRULLINA (C. O. Sm.) Gross., on cucumber fruit collected in Florida, 1917. This was the perithecial stage, but no spores were obtainable from this material.

From a study of these herbarium specimens it is apparent that even these do not conform with the usually accepted ideas of the genera *Phoma, Ascochyta* and *Diplodina*. In fact, taking into consideration the lack of any perithecial stage it would seem that the two herbarium specimens from the Ministry of Agriculture (No. 1 and No. 2) and those from the Kew Herbarium (Nos. 5, 6, and 7) should certainly not be placed in the genus *Mycosphaerella*.

The circumstances point to the fact that, contrary to the usually accepted idea, the species *Mycosphaerella citrullina* (C. O. Sm.) Gross.(6) has not yet been found in England. It should therefore be deleted from the list of British species known at present. The cultural characters and general behaviour of authentic specimens of *Mycosphaerella citrullina* from America, do not agree with any of the fungi isolated from tomatoes in this country.

Cooke's fungus, *Phoma Lycopersici*, should certainly be placed in a different genus (*Diplodina*) as nearly all the spores are septate.

Taking into consideration the extreme variability of the genera *Phoma* and *Diplodina* we have classified the forms under investigation in the following manner, although it is doubtful if a sharp line can be drawn between Series 1 and Series 2:

Series 1.

True *Phoma destructiva* (Plowr.) C. O. Jamieson as defined by *Form A*, an authentic culture.

Forms B, H and Q.

So far in this country these forms have only been found on tomato fruits, although in America this fungus is able to cause also a disease of the leaves and stems.

Series 2.

Intermediate in type between *Phoma* and *Diplodina*. Septation of spores variable, but there are always some spores septate and the spores are usually larger than in Group *A*.

Forms E, F, J, M, P, L.

Included in this group also are herbarium specimens 1, 2, 5, 6, 7 and 8. These forms have been found both on the fruit and on the stem of tomato plants. They differ considerably as regards pathogenicity to the stems under experimental conditions.

These forms are closely allied to one another and probably only represent strains of the same aggregate species. In the present state of our knowledge and methods of analysis, it is considered advisable to attempt to give names only to aggregate species of fungi and not to the smaller elementary species or strains of which the aggregate species consist. It has long been recognised by those who grow fungi in pure culture that many species show numerous forms which can only be differentiated one from the other by minor cultural characters, but under present conditions mycological systematy would become altogether too unwieldly if attempts were made to name these different cultural forms.

It is proposed to place this group of forms as well as herbarium specimens Nos. 1, 2, 5, 6, 7 and 8, in the genus *Diplodina*. It has already been pointed out that, as regards these fungi, the generic distinction between *Phoma* and *Diplodina* has broken down, but in view of the considerable percentage of septate spores in the pycnidia, *Diplodina* has been chosen as the generic name. The name *Ascochyta* is not used as the pycnidia do not occur in spots. Two species of *Ascochyta* have been recorded on decaying tomato leaves (13), *A. Lycopersici* Brun. with spores constricted at the middle, and *A. socia* without median constriction. These species have not been seen by us and have not yet been recorded in Britain. *A. Lycopersici* Brun. may be identical with the fungus now under consideration, but if so, it is preferable to place it in the genus *Diplodina*. Cooke's name *Phoma Lycopersici* (4) is deleted. Plowright's *Sphaeronema Lycopersici* (12) found on tomato fruits may be identical with this, but it has not been possible to obtain the original specimen. It is doubtful whether Plowright* placed his fungus in the right genus as the neck of the pycnidium as figured in his paper is extremely short, and there is no mention of it in the diagnosis. The spores are about the same size as in our forms and the absence of septation is not remarkable. In view of these considerations and of the apparent loss of the type specimen, it seems advisable also to delete the name *Sphaeronema Lycopersici*.

In considering the systematic position of this fungus, Mr J. Ramsbottom of the British Museum—to whom we are much indebted for help in the matter of nomenclature—called our attention to the description of *Diplodina Lycopersici* Hollós in Saccardo's Sylloge Fungorum (13). Although it has not been

* Since this was written, Mr W. B. Grove informs us that Plowright's idea of *Sphaeronema* depended upon the presence of a "globule" of extruded spores at the mouth of the pycnidium, and not upon the presence of a "beak" as understood by Saccardo.

possible to examine this type specimen, which is in Hungary, the description, meagre as it is, fits in well with the fungus now under consideration; these fungi are therefore probably identical. It is thought advisable, however, to amplify Hollós' description, and the fungus will be named *Diplodina Lycopersici* (Cooke) Hollós emend. Brooks and Searle*.

Diplodina Lycopersici (Cooke) Hollós emend. Brooks and Searle.

Pycnidia scattered to aggregate, subcutaneous but subsequently erumpent, glabrous, brown to brownish-black, subglobose, slightly papillate, ostiolate (usually one sometimes 2–3 pores), 100–270 μ in diameter; pycnospores issuing in coils through the ostiolum, forming a dirty white to flesh-coloured exudate; hyaline; continuous to 1-septate (the percentage of septate spores is very variable), slightly constricted at the septum, 2-guttulate, or devoid of guttules, 4·5–17 μ × 2·5–5 μ (average 9·4 μ × 4 μ), sub-cylindrical, produced singly as unbranched conidiophores. No definite stroma; no perithecial stage observed. Parasitic on green and ripe fruits of tomatoes, causing a soft rot, also on the stems, especially just above soil level.

It is considered that the fungus, isolated both from tomato stems and tomato fruits, which was the subject of investigation by one of us(2) some years ago was identical with this. It was then shown that the so-called tomato "canker" fungus was capable of causing a rot of the fruit, and that the same fungus isolated from rotting fruits was able to induce a "canker" of the stem†.

Series 3.

Pycnidial form accompanied by *Alternaria* spores on the same mycelium.

Form C.

It is proposed to name the fungus obtained from tomato fruits *Phoma alternariaceum* Brooks and Searle.

Phoma alternariaceum Brooks and Searle.

Pycnidia aggregate, glabrous, brown to black, subglobose, slightly papillate, ostiolate (usually one, sometimes two pores),

* Since this paper was written, a description of tomato "canker" as it occurs in Germany has appeared (Klebahn, N., "Der Pilz der Tomatenstengelkrankheit und seine Schlauchfruchtsform," Zeitschrift für Pflanzenkrankheiten, XXXI, 1921, p. 1) Klebahn also refers the fungus to *Diplodina Lycopersici* Hollós. He has, moreover, found the perithecial stage, which he names *Didymella Lycopersici*.

† During the summer of 1921, the stem canker form of this disease was received both from this country (through Mr A. D. Cotton) and from Holland (through Dr C. Schoevers). In each the fungus was identical with *Diplodina Lycopersici* (Cooke) Hollós.

100–250 μ in diameter; pycnospores issuing in coils, through the ostiolum, forming a flesh-coloured exudate; hyaline, continuous, sometimes faintly bi-guttulate, 3–7·6 μ × 2–3·5 μ (average 6 μ × 3 μ), ovate with a tendency to pointed ends, produced singly on unbranched conidiophores. Pycnidia accompanied by aerial mycelium bearing spores of the *Alternaria* type produced in chains. *Alternaria* spores 40–80 μ × 12–18 μ, multiseptate, dark brown. On green and ripe tomato fruits, causing a rot.

The following diagnosis in Latin has been kindly drawn up by Mr Gepp and Mr Ramsbottom of the British Museum:

Phoma alternariaceum Brooks and Searle.

Pycnidiis aggregatis, glabris, brunneis atrisve, subglobosis, papillulatis, ostiolatis, poro (interdum poris duobus) pertusis, 100–250 diam.; sporulis poro erumpentibus et cirrum roseolum protrudentibus, hyalinis, continuis, interdum obscure bi-guttulatis, 3–7·5 μ × 2–3·5 μ (plerumque 6 μ × 3 μ), ovatis utrinque subacutis, e sporophoris simplicibus singulariter orientibus.

Pycnidiis mycelio aerio sporas typi *Alternariae* catenatis gerenti se sociantibus. Sporis *Alternariae* 40–80 μ × 12–18 μ, multiseptatis, atrobrunneis.

In Lycopersici fructibus viridibus maturisque, et pulpam putrefaciente.

In consulting the literature on *Alternaria* and *Phoma*, only two species of the latter have been found, in the life-cycle of which an *Alternaria* form has been described. These are two saprophytic species, *Phoma Richardiae* and *Phoma fictilis* mentioned by Miss Westerdijk and Miss van Luijk(16) as having been grown by them. Many years ago, Kohl(8) in trying to clear up the obscurities concerning the spore forms of *Pleospora herbarum*, found a fungus, the pycnospores of which gave *Alternaria* spores as well as pycnidia in pure culture, but this species was not named, nor was it genetically connected with the *Pleospora*. It is interesting to note in this connection that Brefeld(1) found *Alternaria* stages, but not pycnidia, in the life-history of *Pleospora vulgaris* and *Pleospora infectoria*, while in *Pleospora herbarum* the accessory spore form was *Macrosporium commune*.

Some years ago Massee(10) described a disease of tomato fruits caused by *Macrosporium tomato* and stated that pycnidia forming hyaline conidia accompanied the multiseptate spores, although no proof was brought forward that the two spore forms were genetically connected. In our investigations, species of *Macrosporium* have frequently been seen on diseased tomato fruits but upon isolation have always proved to be non-pathogenic. It seems likely that Massee's account of a tomato fruit

disease was based upon a mixture of forms. In America it has been shown by Rosenbaum and Sando* that *Macrosporium tomato* Cke. may be the cause of a disease of uninjured tomato fruits.

Series 4.

This includes the forms *K*, *K* 2, and *S* with the authenticated culture of *Colletotrichum phomoides* (Sacc.) Chest. (Form *D*).

As has been noted by Shear and Wood (15 p. 64) in dealing with the ascomycetous genus *Glomerella*, the conidial stage (*Gloeosporium* or *Colletotrichum*) shows great variability in its mode of formation and in morphological characters. In some cultures the conidia are borne on scattered conidiophores and in others large compact acervuli occur. Later these authors point out that setae are also a variable factor, being entirely absent in some cultures and present in others.

This variability was also noted by us in the four forms studied, and again, as in Series No. 2, makes the taxonomic arrangement of the forms very difficult.

In comparing the forms *K*, *K* 2, and *S* with the authenticated culture (*D*) of *Colletotrichum phomoides* (Sacc.) Chest.(3) it was found that form *S* was identical with the latter, except that setae were not always produced in artificial media, although when transferred to tomato fruits setae were abundantly formed. The acervuli varied from 180–360 μ in diameter and the conidia were borne at the apex of short branched conidiophores. The conidia were usually cylindrical with rounded or slightly pointed ends, very regular in shape and size, and always unicellular. The cell contents were very granular.

The great majority of conidia were uniform in size at 21 $\mu \times 4\,\mu$, though conidia were seen varying between 14 μ to 24 $\mu \times 3\,\mu$ to 4·5 μ. This form can therefore be undoubtedly diagnosed as *Colletotrichum phomoides* (Sacc.) Chest., and is, we believe, its first recorded appearance in England.

The forms *K* and *K* 2 were identical one with the other but both slightly differed from forms *D* and *S*, since, on artificial media large compact black acervuli were very seldom formed, the conidia being borne on cushion-like loose aggregations of conidiophores. Spore-formation seemed to be much more profuse than in the other forms, as the spores were produced in such abundance that the whole surface of the fruit was covered with pink masses of conidia almost coalescing one with another. Some conidia were very slightly curved; they were all non-septate, very uniform in size and vacuolate. Setae were not observed. The size of the conidia in *K* varied from 19 μ to

* Rosenbaum, J. and Sando, C. E. Correlation between size of fruit and its relation to infection with *Macrosporium tomato*. Amer. Journ. Bot., 1920.

30 μ × 5 μ to 8 μ, and of *K* 2 from 14 μ to 30 μ × 5 μ to 7·5 μ, 20 measurements being taken in each case.

Mention has already been made that form *K* 2 produced typical acervuli on one artificial medium, so that it seems probable that these two forms can also be provisionally included under the species *Colletotrichum phomoides*.

Series 5.

Series 5 consists only of form *N* which was a typical species of *Fusarium*.

On Dox's agar, the colour of the spores in mass was orange salmon. The spores were crescent-shaped with pointed ends, 2–4 times septate, 3–4 μ × 24–36 μ. When fully mature, one cell of the spore was often thick-walled and apparently functioned as a resting spore. Two species of *Fusarium* are recorded by Saccardo(13) as occurring on tomato fruits, *F. aurantiacum* Link, and *F. oxysporum* Schlecht. var. *Lycopersici* Sacc., but in the absence of comparative cultures, it is impossible to identify the species. It is probable that many species of this genus would cause a rot of tomato fruits if inserted in them through wounds, and in fact a pure culture of *Fusarium caeruleum* obtained from potatoes, produced a soft rot.

GENERAL CONSIDERATIONS.

It would appear from this review of a number of forms of fungi parasitic on the tomato fruit that the whole question of the taxonomy of difficult genera like *Phoma*, *Ascochyta*, *Diplodina*, *Colletotrichum* and *Glocosporium* is one requiring considerable attention from systematists. At present the species in these genera are almost numberless and seem to be added to on very slender grounds and without much regard to the true relationships between them, which can only be determined by careful cultural work. To add new species indiscriminately on the grounds of host relationship, or on a variation in some small morphological detail, which if studied in cultural form will often turn out to be within the "experimental error" or ordinary range of variability, is much to be deplored and adds largely to the difficulties of later investigators. In the forms here investigated, this variability was found to be very marked, especially in such morphological details as septation of spores, a character often looked upon as specific and one in which some systematists beg the question by adding such phrases as "becoming septate later" or "the septation is tardy in appearing."

SUMMARY.

Various rots of tomato fruits and certain diseases of the stems of tomato plants have been investigated. These fruit rots commonly occur both on imported and upon home-grown fruit, and are caused by several different fungi about the identity of which there has been much uncertainty. The fungi isolated from rotten tomatoes have been compared with authentic cultures of certain presumably identical or closely related fungi from the United States. One of the rots is caused by *Phoma destructiva*, the British form of which is identical with that from America. Another of these rots is produced by a fungus which has hitherto passed in this country under the name of *Mycosphaerella citrullina*, but which is certainly not identical with the American fungus of that name. The British fungus which has hitherto been mistaken for this and which causes tomato stem "canker" as well as a fruit rot, appears to be identical with *Diplodina Lycopersici* Hollós which name also replaces *Phoma Lycopersici* Cooke. It has been considered advisable to amplify Hollós' description and the fungus is therefore named *Diplodina Lycopersici* (Cooke) Hollós, emend. Brooks and Searle. Another pycnidial fungus, found only once as the cause of a tomato rot, is associated with an *Alternaria* stage, and the name proposed for this fungus is *Phoma alternariaceum* Brooks and Searle. Finally, various strains of *Gloeosporium* and *Colletotrichum* parasitic on tomatoes have been isolated. One of these fungi is identical with the American *Colletotrichum phomoides* (Sacc.) Chester, and probably all of these forms are thus best grouped.

The desirability of undertaking cultural sudies of fungi belonging to such genera as *Phoma*, *Diplodina*, and *Colletotrichum* as an aid in the diagnosis of species, is emphasised.

POSTSCRIPT.

Since this paper went to press, Petrak, in a note "Über die Schwarzfäule der Tomaten" (Annales Mycologici, 1921, p. 17), describes a fungus occurring on the leaves, stems, and fruits of the tomato, which he considers identical with Plowright's *Phoma destructiva*, but which he now names *Diplodina destructiva* (Plowr.) Petrak, because of the uni-septate character of the pycnospores formed on the leaves and stems although the spores are almost entirely non-septate in pycnidia on diseased fruits. Petrak's survey of the literature on this and allied tomato diseases is very incomplete, and, in the absence of inoculation and cultural experiments, it is by no means certain that he was dealing with one fungus only. As pointed out in our paper, it is doubtful whether a sharp line can be drawn between *Phoma destructiva* (Plowr.) C. O. Jamieson, and *Diplodina Lycopersici* (Cooke) Hollós, but in view of the above considerations and of the constantly non-septate character of the spores obtained both by Miss Jamieson and ourselves from certain forms of fruit disease, even under cultural conditions, it seems desirable to retain both these names. As stated previously, the generic distinctions between *Phoma* and *Diplodina* seem to have broken down in this group of fungi, and we appear to be dealing here with a series of closely-related forms, rather than with clearly-defined species.

BIBLIOGRAPHY.

(1) Brefeld, O. Untersuchungen aus dem Gesammtgebiete der Mykologie, Heft x.
(2) Brooks, F. T. and Price, S. R. A disease of tomatoes. New Phyt. vol. xii, 1913.
(3) Chester, F. D. The ripe rot or anthracnose of tomato, *Colletotrichum phomoides*, Sacc. 6th Ann. Rep. Delaware Coll. Agric. Expt. Stn. 1894.
(4) Cooke, M. C. New British Fungi. Grevillea, vol. xiii, 1885, p. 94.
(5) Dox, A. W. The intracellular enzymes of lower fungi, especially those of *Penicillium camemberti*. Journ. Biol. Chem. 1909, vol. vi, p. 461.
(6) Grossenbacher, J. G. A *Mycosphaerella* wilt of melons. New York Agric. Expt. Stn. Tech. Bull. No. 9, 1909.
(7) Jamieson, Clara O. *Phoma destructiva*, the cause of the fruit rot of the tomato. Journ. Agric. Research, vol. iv, 1915.
(8) Kohl. Über den Polymorphismus von *Pleospora herbarum* (Tul.). Bot. Centralbl. Bd. xvi, p. 26, 1883.
(9) Massee, G. Cucumber and Tomato canker. Kew Bulletin, 1909.
(10) —— Diseases of cultivated plants and trees, London, 1910.
(11) Peck, C. H. Report of the Botanist, 40th Ann. Rep. New York State Museum, 1886, p. 57.
(12) Plowright, C. B. On the fungoid diseases of the Tomato. Gard. Chron., 1881, p. 260.
(13) Saccardo, P. A. Sylloge fungorum, vols. iii, iv, x and xxii.
(14) Schoevers, T. A. C. De tomatenkanker. Tijdschrift over Plantenziekten, xxv, 1919, p. 174.
(15) Shear, C. L. and Wood, Anne K. Studies of fungous parasites belonging to the genus *Glomerella*. U.S. Dept. Agric., Bur. Plant Industry, Bull. 252, 1913.
(16) Westerdijk, J. and Van Luijk, A. Die Kultur der *Phoma* Arten. Mededeelingen uit het Phytopathologisch Laboratorium "Willie Commelin Scholten," Amsterdam, 1920, p. 26.

HOMOTHALLISM AND THE PRODUCTION OF FRUIT-BODIES BY MONOSPOROUS MYCELIA IN THE GENUS COPRINUS.

With Plates VI and VII.

By Miss Irene Mounce, M.A. (British Columbia).

I. Introduction.

In a publication entitled "Recherches sur le cycle évolutif et la sexualité chez les Basidiomycètes" Mlle M. Bensaude* records the results of certain experiments and cytological observations which appear to show that *Coprinus fimetarius*—one of the Basidiomycetes—resembles certain Mucorini investigated by Blakeslee in that it is *heterothallic*.

In making cultures of *Coprinus fimetarius* in Van Tieghem cells, Mlle Bensaude obtained four mycelia, each of which had originated from a single spore. These four monosporous mycelia were transferred to tubes, but only two of them survived this change of conditions and continued to grow. The two surviving monosporous mycelia, α and β, were sub-cultured; but during eight months they remained in the *primary* condition, *i.e.* none of them developed clamp-connections or paired nuclei, and they all proved quite *sterile*, for none of them produced any fruit-bodies. On the other hand, the behaviour of a mycelium of polysporous origin was quite different. Mlle Bensaude obtained polysporous mycelia by mixing pieces of the mycelia of mycelium α and mycelium β. She found that, as a result of hyphal fusions taking place between α and β, a mycelium was produced which was definitely secondary in nature, for its nuclei were paired and divided conjugately, the division of each dicaryon was accompanied by the formation of a septum with a clamp-connection, and the mycelium as a whole was fertile, as was shown by the production of fruit-bodies.

Mlle Bensaude's criteria for determining heterothallism in her fungus were: (1) the isolated condition of the nuclei and the absence of clamp-connections in monosporous mycelia, (2) the formation of dicaryons and clamp-connections when two different mycelia, α and β, were brought together so that they might anastomose with one another, and (3) the sterility of

* Mathilde Bensaude, Recherches sur le cycle évolutif et la sexualité chez les Basidiomycètes, Nemours, 1918, pp. 1–156, nine plates.

monosporous mycelia and the fertility of the compound bisporous mycelia.

Hans Kniep who has also investigated the sexuality of the Hymenomycetes, accepts the first two of Mlle Bensaude's criteria for heterothallism but not the third. He has made the remarkable discovery that the fruiting of a mycelium of a heterothallic Hymenomycete, *e.g. Schizophyllum commune*, does not necessarily depend upon the nuclei in the mycelium becoming paired, so that a haploid mycelium derived from a single spore may produce fruit-bodies resembling in external appearance and in the production of numerous ripe spores the fruit-bodies of the same species produced on a diploid mycelium derived from the fusion of two monosporous mycelia of opposite sex*. Hence the mere formation of fruit-bodies by a monosporous mycelium is no clear indication that the fungus is homothallic; for, notwithstanding its fruit-bodies, it may be heterothallic. According to Kniep, in a heterothallic species, the difference between a haploid fruit-body produced by a monosporous mycelium and a diploid fruit-body produced by a compound mycelium which has originated from two mycelia of opposite sex lies in this: that each basidium of a haploid fruit-body has only one nucleus in it when it is cut off from its parent subhymenial cell, whereas each basidium of a diploid fruit-body, when cut off, always contains two nuclei. In the haploid basidium, the single nucleus divides twice; whereas, in the diploid basidium, the two original nuclei first fuse together and the fusion nucleus divides twice. Thus in the haploid basidium there is no nuclear fusion, whereas in the diploid basidium such a fusion always takes place. According to Kniep, in a heterothallic species all the spores of a haploid fruit-body are of the same sex, whereas those of a diploid fruit-body are divided into groups which are sexually different.

Kniep† and Mlle Bensaude‡, working independently, have both found that the formation of clamp-connections in the mycelium of any Hymenomycete is associated with the conjugate division of the nuclei. Hence the existence of clamp-connections in a mycelium is an outward and visible sign of the fact that the nuclei in the mycelium exist not as isolated units but in the paired state, *i.e.* as dicaryons. If, therefore, in any species of Hymenomycete, one finds clamp-connections always forming in individual mycelia of monosporous origin, one is justified in concluding that the species is homothallic; but if clamp-

* Hans Kniep, Über morphologische und physiologische Geschlechtsdifferenzierung. Verhandl. der Physikal.-med. Gesellschaft zu Wurzburg, 1919, p. 10.

† Hans Kniep, Beiträge zur Kenntnis der Hymenomyceten, III, IV and V. Zeitschr. f. Botanik, VII, 1915, VIII, 1916, and IX, 1917.

‡ Mlle Bensaude, *loc. cit.*

connections are not found in such monosporous mycelia but only in compound mycelia formed by the union of two mycelia presumably of opposite sex, then one is justified in concluding that the species is heterothallic.

Kniep, when working with *Schizophyllum commune* which is heterothallic, discovered that when a heterothallic species produces a fruit-body from a mycelium of monosporous origin, not only is the fruit-body haploid but all the spores which it produces are of the same sex. Evidence of this fact was obtained by sowing the spores of a haploid fruit-body in large numbers together in the same culture medium and by observing that clamp-connections were never formed in the compound mycelium which resulted. The nuclei in the compound mycelium just described, therefore, never arranged themselves in the form of dicaryons. Assuming these facts to be true, we are provided with a second criterion for determining whether a species which produces clamp-connections is homothallic or heterothallic. If clamp-connections are found in a compound mycelium arising from the sowing of numerous spores obtained from a fruit-body of monosporous origin, then we are justified in supposing that the species is homothallic; but, if no clamp-connections are formed, then the species is heterothallic.

Kniep*, using the clamp-connection criteria, states that he has proved experimentally that the following species of Hymenomycetes are heterothallic:

Polyporus versicolor.	*Mycena calopus.*
Typhula erythropus.	*M. parabolica.*
Peniophora corticalis.	*Clitocybe infundibuliformis.*
Stereum purpureum.	*Hypholoma fasciculare.*
Schizophyllum commune.	*H. sublateritium.*
Marasmius alliaceus.	*H. capnoides.*
Armillaria mucida.	*H. Candolleanum.*
Collybia butyracea.	*H. hydrophilum.*
C. asema.	*Pholiota mutabilis.*
C. tuberosa.	*P. praecox.*
C. velutipes.	*Coprinus stercorarius.*

He also states that homothallic Hymenomycetes exist and cites as examples:

Hypochnus terrestris.	*Stereum hirsutum.*
Typhula sp.?	

In view of the importance of Mlle Bensaude's conclusion that certain Basidiomycetes are heterothallic, it seemed desirable, if possible, to repeat her experiments with a number of different species. At the suggestion of Professor Buller, therefore, I have

* Hans Kniep, Über morphologische und physiologische Geschlechtsdifferenzierung, *loc. cit.* pp. 12 and 13. This list is given in a foot-note without further details.

made a series of experiments on the fruiting powers of monosporous and polysporous mycelia of a number of species of Coprinus occurring on horse dung at Winnipeg. These coprophilous fungi yield an abundance of fruit-bodies spontaneously on unsterilised horse dung, can be readily grown in pure culture from spores, complete their life-histories in a very few weeks, and have black or dark brown spores which stand out conspicuously in agar plates when examined under the low power of the microscope. They were thus well suited to serve as material for my investigations. Kniep's papers became available six months after the work was begun.

Until the investigations here described were almost completed, I thought, like Mlle Bensaude, that if a monosporous mycelium of any species could produce fruit-bodies, evidence was thereby obtained which proved that the species is homothallic and not heterothallic. However, as soon as Kniep's 1919 paper came into my hands, I perceived that the criterion of fruit-body production is insufficient for determining the question of homothallism and heterothallism. I have not made any cytological studies either of mycelia or fruit-bodies. For determining that any species of Coprinus is homothallic and not heterothallic, I have relied upon two criteria only: (1) the occurrence of clamp-connections upon mycelia of monosporous origin, and (2) the occurrence of clamp-connections or compound mycelia arising from spores all of which have been derived from a single fruit-body produced from a mycelium of monosporous origin. The value of these two criteria has already been discussed.

Monosporous mycelia have been successfully isolated and cultivated for the following nine species:

Coprinus sterquilinus Fr.
C. lagopus Fr.
C. stercorarius Fr.
C. niveus Fr.
C. ephemerus Fr.
C. curtus Kalchb.
C. stellatus Buller.
C. cordisporus Gibbs.
C. comatus Fr.

The name *Coprinus stellatus* at present is a *nomen nudum*. The variety of *Coprinus ephemerus* made use of was purplish in colour. This form occurs both in England and Canada. Altogether, for the nine species, fifty-six monosporous mycelia were successfully transferred to culture media. Of these fifty-six mycelia all except three (one of the *C. niveus* cultures and the two *C. comatus* cultures) produced fruit-body rudiments; but, as we shall see, in many of the cultures, the rudiments never developed into mature fruit-bodies shedding spores.

II. Methods.

Horse-dung balls were collected from stables and from the streets of Winnipeg and were placed in a large glass chamber set on a table in the laboratory. In the course of a few weeks, fruit-bodies of the nine species of Coprinus named above, with the exception of *Coprinus comatus*, appeared on the dung balls. Spore-deposits were collected on sterilised filter paper by placing this beneath pilei which were shedding spores. When a spore-deposit had been obtained, the filter paper bearing it was labelled and set in a sterilised glass container. It was then ready for use at any time.

Experiments were made with beef-peptone agar, beef-peptone gelatine, malt gelatine, and potato agar; but the medium used for all the later experiments was a horse-dung decoction solidified with 1·3–2 per cent. agar. This culture medium was made as follows. Approximately 400 grams of fresh horse-dung were put in a beaker with 1000 cc. of tap-water and the whole was placed in a steam steriliser at a temperature of 100° C. for 30 minutes. To the decoction so obtained was then added 1·3–2 per cent. of melted agar. The horse-dung agar was then filtered through cotton-wool, and, thereafter, 10 cc. of it was poured into each of a series of test-tubes. These tubes, which were plugged with cotton-wool, were then autoclaved at a pressure of seven pounds for half an hour or longer. The medium was not titrated.

To isolate the monosporous mycelia, the poured plate or Petri dish method was employed. Tubes of horse-dung agar which had been melted and cooled to a temperature of 42°–45° C., were inoculated with a few spores introduced by means of a sterilised platinum needle from a spore-deposit. The agar was then poured into sterilised Petri dishes. The dishes were placed in a cupboard and kept at room temperature, *i.e.* at about 20°–22° C. After from two to five days, varying with the species, minute mycelial masses could be seen with the naked eye upon the agar; and, with the low power of the microscope, it was found that some of these had developed from small clumps of spores and others from single spores (Pl. VI, Figs. 1, 2, 5, 10). The spores could be very readily distinguished owing to their blackness. When a mycelium was found to have developed from a single spore which was far distant from any other spore or mycelium, it was removed from the Petri dish with a sterilised platinum needle and transferred to a dung-agar slant. Usually within two to four days the mycelium had extended itself considerably over the agar surface. It was then finally transferred, along with the agar which it covered, to a

wide glass tube (length 4 inches, breadth 1·25 inches) which, after having been half filled with fresh horse-dung and plugged with cotton-wool, had been sterilised in flowing steam for 45 minutes on three successive days. This tube was set in a cupboard or on a table away from direct sunlight and kept at room temperature.

Whilst isolating monosporous mycelia of any species, a polysporous mycelium which had originated from several germinating spores of a spore clump, was also isolated; and it was transferred first to a slant and then to a wide tube in the same manner as, and at the same time as, the monosporous mycelia. Thus controls were provided.

III. *Coprinus sterquilinus.*

The first experiments were made with *Coprinus sterquilinus*, a species which has very large black spores, a rapidly-growing dense white mycelium, and a large fruit-body*. Potato agar was employed for the plates and slants in the earlier cultures, and dung agar in the later ones. The methods of cultivation were identical with those described above except in the last few cultures where I transferred the monosporous mycelia directly from the Petri dish to the tubes of sterilised dung. Altogether twenty-five monosporous mycelia were isolated, but four of them failed to grow after being transferred. Each of the twenty-one mycelia which survived transference, grew well and completely covered the horse-dung balls with a white felt-work. A considerable number of rudimentary fruit-bodies soon appeared on the mycelium covering the dung balls; and, after 24–31 days from the time the spores were first sown, some of the fruit-bodies elongated their stipes, expanded their pilei, and shed great numbers of spores. Thus each of the twenty-one monosporous mycelia fruited in a perfectly normal manner.

Included in the twenty-one monosporous cultures was a series which may be described as follows. A wild fruit-body came up on horse-dung taken from a stable, and it shed spores which were collected as a spore-deposit. Some of the spores were plated out on agar and thus a monosporous mycelium was obtained. A month after being transferred to sterilised horse-dung in the usual way, the mycelium fruited. From this second fruit-body, a second monosporous mycelium was obtained which at the end of a second month also fruited; and from the third fruit-body a third monosporous mycelium was obtained which

* For a description of the fruit-body with illustrations *vide* A. H. R. Buller, Die Erzeugung und Befreiung der Sporen bei *Coprinus sterquilinus*, Pfeffer's Festschrift, identical with Jahrb. f. wiss. Bot. LVI, 1915, pp. 299–329, Taf. II and III.

at the end of the third month also fruited; and so on for five successive generations. If we let S = a single spore, MM = a monosporous mycelium, and F = a fruit-body, then the sequence just described may be set forth as follows:

$$F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow$$
$$(S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F).$$

Thus fruit-bodies of *Coprinus sterquilinus* were obtained in monosporous cultures for five successive generations*. The first fruit-body of the fifth generation is shown in Plate VII, Fig. 1.

Experiments with twenty-one monosporous cultures of *Coprinus sterquilinus* has taught me that this fungus fruits from mycelia of monosporous origin with remarkable certainty and perfection. In a monosporous culture of this species one can rely upon seeing fruit-body rudiments appear at the surface of the dung after about a fortnight from the sowing of the spores, and one can also rely upon obtaining mature fruit-bodies, producing vast numbers of spores, from some of the same rudiments at the end of about a month from the time of the sowing of the spores. All the monosporous cultures of *Coprinus sterquilinus*, therefore, behave in exactly the same manner so far as fruiting is concerned.

We may now ask: is *Coprinus sterquilinus* homothallic or heterothallic? Accepting Kniep's view that the production of fruit-bodies on a monosporous mycelium is no proof that the species is homothallic, it is therefore necessary for us to answer our question by the criterion of clamp-connections. I found that all the mycelia of monosporous origin which I studied after the first few days of their development, even those of the fifth successive generation, exhibited clamp-connections with great regularity on all the stout hyphae radiating from the centres of growth (Plate VI, Figs. 3 and 4). It seems to me, therefore, that there can be no doubt that *Coprinus sterquilinus* is a homothallic species.

Polysporous mycelia arising from the union of the mycelia, coming from several spores sown in a clump, were isolated from agar plates and grown side by side with monosporous mycelia as controls. No difference between the polysporous mycelia and the monosporous ones could be observed as regards rapidity of appearance of mycelial growth, presence of clamp-connections, rapidity of fruiting, or in the perfection of the fruit-bodies produced. The polysporous cultures fruited sometimes a day or

* Since this was written, fruit-bodies have been obtained from a sixth successive monosporous culture.

two ahead of the first monosporous cultures and sometimes a day or two later. There was nothing to show that a polysporous culture has any more vigour than a monosporous culture.

Although it appears that *Coprinus sterquilinus* is undoubtedly homothallic and that it is perfectly vigorous when its nuclei become paired as a result presumably of hyphal fusions taking place between branches of the same mycelium; yet, under natural conditions, crossing is by no means excluded and probably often takes place. When several spores germinate together, as they must often do in horse-dung in fields, the mycelia doubtless soon anastomose. Thus the condition is provided, even in a homothallic species, for the first dicaryon to arise by a nucleus of one mycelium moving across a bridging hypha to another mycelium and thus pairing with one of the latter's nuclei. An analogy is provided by certain hermaphrodite Flowering Plants in which either self-pollination or cross-pollination may take place.

IV. *Coprinus lagopus.*

Coprinus lagopus, which was the second species studied, comes up very commonly on unsterilised horse-dung cultures in both Europe and North America. The fruit-bodies obtained at Winnipeg fit the description of *C. lagopus* as given in Lange's monograph on the genus Coprinus*, and they also correspond in detail with the illustrations of *C. lagopus* as given by Brefeld†.

Ten monosporous mycelia and one bisporous mycelium of *Coprinus lagopus* were isolated from dung-agar plates, transferred individually to dung-agar slants, and finally transferred to wide tubes containing sterilised horse-dung. Within fourteen days from the time the spores were plated out from the spore-deposit, the mycelia on the eleven agar slants all showed rudimentary fruit-bodies; and, subsequently, in nine out of the ten monosporous cultures as well as in the bisporous culture, some of the fruit-bodies expanded. The bisporous mycelium produced a fruit-body one day after the monosporous ones, but otherwise behaved precisely as they did. The monosporous dung cultures varied somewhat in the length of time they took to develop. Transferring the mycelium to the dung seemed to check the growth of some of them temporarily. Seven of them produced rudimentary fruit-bodies seven days after transference to dung, one nine days after, one ten days after, and the last sixteen days after transference. The bisporous mycelium de-

* Jacob E. Lange, Studies in the Agarics of Denmark, Dansk Botanisk Arkiv, Bd. II, Copenhagen, 1915, p. 41.

† O. Brefeld, Untersuchungen, Leipzig, Heft III, 1877, Taf. VI, fig. 1, *a–g*.

veloped fruit-bodies one day before the first monosporous mycelium. Although all the eleven dung cultures produced rudimentary fruit-bodies, in only six of them did the rudiments continue their development to maturity. This, however, appeared to be due to the conditions of nutrition, aeration, transpiration, etc.; for, when transfers were made to large masses of sterilised dung contained in crystallising dishes, fruit-bodies were produced which elongated their stipes, expanded their pilei, and shed spores in the normal manner (Plate VII, Fig. 2).

Later, an eleventh monosporous mycelium was removed from a dung-agar plate and placed directly in a large crystallising dish of horse-dung which had been sterilised by heating on three successive days. This culture showed very little surface mycelium but eventually produced several large normal fruit-bodies.

All the fruit-bodies produced in the monosporous and the bisporous agar-tube and dung-tube cultures were imperfect, *i.e.* their pilei produced no ripe spores and, at maturity, were, therefore, white or pale yellow instead of being grey. However, when monosporous mycelia were transferred from the tubes to sterilised horse-dung contained in large crystallising dishes, they produced many perfect spore-bearing fruit-bodies, as well as some which produced many spores which never ripened, very few ripe spores, or no spores at all. This imperfection of certain of the fruit-bodies in each large pure culture, in respect to spore-production, was observed not only in all the monosporous cultures, but also in all the polysporous cultures. Altogether seventeen cultures exhibited imperfect spore-production and, of these, ten were monosporous in origin and seven polysporous. Since the fruit-bodies of both monosporous and polysporous pure cultures behave in the same manner as regards imperfection of spore-production, this phenomenon cannot be due to the haploid or diploid condition of the mycelium but must be due to some other cause, such as the over-production of fruit-bodies of large size or to the absence from the nutrient medium of certain chemical compounds which in unsterilised dung are ordinarily produced by associating and competing organisms.

A wild fruit-body of *Coprinus lagopus* came up on horse-dung taken from a stable, and it shed spores which were collected as a spore-deposit. Some of the spores were plated out on agar and thus a monosporous mycelium was obtained. This mycelium was transferred to sterilised horse-dung in a large crystallising dish. Here it fruited nineteen days after the spore from which it originated had been sown. From this second fruit-body a second monosporous mycelium was obtained which also fruited.

Using the same symbols as before, the sequence may be expressed as follows:

$$F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F).$$

Thus fruit-bodies of *Coprinus lagopus* were obtained in monosporous cultures for two successive generations.

Judged by the criterion of the appearance of clamp-connections in a mycelium of monosporous origin, *Coprinus lagopus* is homothallic, for clamp-connections developed: (1) on each of several mycelia of monosporous origin derived from the spores of a wild fruit-body (Plate VI, Figs. 6 and 7), and (2) on each of three mycelia of monosporous origin derived from spores produced by a fruit-body of monosporous origin. This conclusion is confirmed by the fact that clamp-connections also appeared on (3) a compound mycelium of polysporous origin derived from many spores produced by a fruit-body of monosporous origin (Plate VI, Fig. 8). Were *Coprinus lagopus* heterothallic, instead of being homothallic, no clamp-connections should have developed on any of the three kinds of mycelia just described.

Judging by Mlle Bensaude's illustrations and description of *Coprinus fimetarius*, it seems not improbable that this species is identical with the one which, upon the advice of Professor Buller, I call *C. lagopus*. A *Coprinus fimetarius* distinct from *C. lagopus* and coming up on unsterilised horse-dung has not been found at Winnipeg, and my *Coprinus lagopus*, as Professor Buller has proved by comparative cultures, is the same as the *C. lagopus* which so commonly comes up on unsterilised horse-dung in laboratory cultures in England. Certainly Mlle Bensaude's *C. fimetarius* and my *C. lagopus* have fruit-bodies which appear to me to be identical in external appearance. Even if, after all, Mlle Bensaude's species should prove to be different from my *C. lagopus*, it will be necessary to admit that the two species are very closely related; and it is, therefore, not a little remarkable that they should behave so differently as regards sex, Mlle Bensaude's species being heterothallic and my own homothallic.

V. *Coprinus stercorarius.*

The third species investigated was the well-known *Coprinus stercorarius* the life-history of which was described by Brefeld*, and which is remarkable in that it produces small black sclerotia the size of dried peas. After plating out some spores from a wild fruit-body, two monosporous mycelia were obtained, which, after being transferred to dung-ball tubes in the usual way,

* O. Brefeld, Untersuchungen, Leipzig, Heft III, 1877, pp. 13–67.

continued growing. Their hyphae scarcely showed themselves on the surface of the dung. However, after twelve days had passed, sclerotia began to develop on the dung in both tubes. These sclerotia which were at first white, grew rapidly in size, excreted large water drops, and then turned black on their exterior, except where they happened to press against the glass. Two ripe sclerotia were removed and placed on wet sterilised sand under a bell-jar; and there, after a few days, they developed normal fruit-bodies which shed vast numbers of spores. Thus for *Coprinus stercorarius* two mycelia of monosporous origin, like similar mycelia of *C. sterquilinus* and *C. lagopus*, fruited in a perfectly normal manner.

A wild fruit-body of *Coprinus stercorarius* came up from a sclerotium which developed spontaneously on horse-dung in the laboratory, and it shed spores which were collected as a spore-deposit. Some of the spores were plated out on agar and thus a monosporous mycelium was obtained. This mycelium, after being transferred to a horse-dung tube, produced a sclerotium, and the sclerotium produced a second fruit-body. From this second fruit-body four monosporous mycelia were obtained. Of these, up to the present, one has produced sclerotia only, one sclerotia and several fruit-bodies directly from the dung, and two fruit-bodies directly from the dung but no sclerotia. Using the same symbols as before, the sequence for a single line may be expressed as follows:

$$F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F).$$

Thus fruit-bodies of *Coprinus stercorarius* have been obtained in monosporous cultures for two successive generations.

In *Coprinus stercorarius*, just as for *C. lagopus*, clamp-connections were found on the following kinds of mycelia: (1) several mycelia of monosporous origin, the spores having been derived from a wild fruit-body, (2) a mycelium of monosporous origin derived from a spore produced by a fruit-body of monosporous origin, and (3) a compound mycelium of polysporous origin derived from spores produced by a fruit-body of monosporous origin (Plate VI, Fig. 9). We may conclude, therefore, just as we did for *C. lagopus*, that *Coprinus stercorarius* is homothallic.

Kniep states, without as yet giving the details of his evidence, that *Coprinus stercorarius* is heterothallic*. My observations which have clearly shown that clamp-connections in *C. stercorarius* appear in monosporous mycelia, do not support Kniep's statement. Judged by the clamp-connection tests, *C. stercorarius* is certainly homothallic.

* Hans Kniep, Über morphologische und physiologische Geschlechtsdifferenzierung, *loc. cit.* p. 13, foot-note.

VI. *Coprinus niveus.*

From the spores of a wild fruit-body five monosporous mycelia were obtained by plating, and they were transferred to dung-tubes in the usual way. Of these five mycelia, two yielded normal fruit-bodies which expanded and shed spores, two yielded rudimentary fruit-bodies which never expanded or shed spores, while one did not produce any rudiments at all. It therefore seems that, in *Coprinus niveus*, some monosporous mycelia fruit very much more readily than others and that some of the mycelia may not be able to fruit at all. It was found that compound mycelia of polysporous origin, the spores having been derived from a wild fruit-body, fruited much more vigorously and several days sooner than any of the monosporous mycelia. Thus *Coprinus niveus*, in contrast with *C. sterquilinus*, is very uncertain in respect to the fruiting of its monosporous mycelia.

Fruit-bodies of *Coprinus niveus* were obtained in monosporous cultures for two successive generations. This result, using the symbols already employed, may be expressed as follows:

$$F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F).$$

In *Coprinus niveus*, just as in *C. lagopus* and *C. stercorarius*, clamp-connections were found in the following kinds of mycelia: (1) several mycelia of monosporous origin, the spores having been derived from a wild fruit-body, (2) two mycelia of monosporous origin derived from two spores produced by a fruit-body of monosporous origin, and (3) a compound mycelium of polysporous origin derived from many spores produced by a fruit-body of monosporous origin (Plate VI, Fig. 11). Hence we may conclude, just as we did for *C. lagopus* and *C. stercorarius*, that *Coprinus niveus* is homothallic and not heterothallic.

Since *Coprinus niveus* is homothallic, it is remarkable that its monosporous mycelia are so very uneven in their power of producing fruit-bodies. It seemed possible that two monosporous mycelia, if allowed to combine in the same culture vessel, might fruit more vigorously from the compound mycelium thus produced than either would fruit if kept isolated by itself. Accordingly sub-cultures were made from three of the five first-made monosporous cultures. Let us call these cultures *A*, *B* and *C*. *A* had produced normal fruit-bodies, *B* only fruit-body rudiments, and *C* no rudiments at all. From these cultures six dung-tube sub-cultures were made as follows:

(1) *A* by itself,	(4) $A + B$,
(2) *B* ,,	(5) $A + C$,
(3) *C* ,,	(6) $B + C$,

and all the cultures were kept under the same external conditions.

The result of the experiment was truly remarkable, for the three mixed cultures all fruited vigorously and their fruit-bodies shed spores 24–28 days after the sub-cultures had been made; whilst, at the end of this time, the unmixed cultures showed not even a single fruit-body rudiment. The culture (1) *A* by itself, showed its first rudiments after about 29 days, but the fruit-body did not expand until the 33rd day. The other unmixed cultures (2) and (3), *B* by itself and *C* by itself, on the 33rd day had not yet shown any rudiments whatever.

From the series of experiments just described, it would seem that *Coprinus niveus*, although homothallic, fruits much more vigorously in mixed cultures than in monosporous ones. This conclusion is an important one, for it seems to indicate that in a homothallic species when two mycelia in the diploid condition are allowed to unite, the compound mycelium resulting may fruit more vigorously than either of its components when separated. Is it possible that, when two diploid mycelia unite, the dicaryons may become rearranged so as to allow of sexual crossing? If so, we might conclude that crossed compound mycelia in *Coprinus niveus* fruit more vigorously than uncrossed or selfed mycelia, and we might appeal for an analogy to the results obtained by Charles Darwin in his experimental studies of cross-fertilisation and self-fertilisation in Flowering Plants. I regret that, up to the time of writing, I have not been able to repeat and extend the experiments which have just been described.

In *Coprinus sterquilinus* and *C. stercorarius* which, like *C. niveus*, are homothallic, a compound mycelium arising from many spores sown together did not appear to fruit any more vigorously or any sooner than monosporous mycelia grown under similar conditions. Hence we may conclude that, although in *Coprinus niveus* the mixing of the mycelia appears to increase the capacity for fruiting, yet this does not hold true for *C. sterquilinus* and *C. stercorarius*.

VII. Other smaller species.

Of *Coprinus ephemerus* Fr. three cultures were made, two monosporous and one polysporous, in dung tubes. All the three cultures produced fruit-body rudiments, but only the polysporous culture produced perfect fruit-bodies. Clamp-connections were found in the polysporous mycelium (Pl. VI, Fig. 12) but were not searched for in the monosporous mycelia.

Coprinus curtus Kalchb., *C. stellatus* Buller (a new and as yet undescribed species of the ephemerus group) and *C. cordisporus* Gibbs (a Canadian form of the species) were also investigated

for fruit-body production and for the development of clamp-connections. These three species appear to be entirely lacking in clamp-connections, for no clamp-connections were found even in their polysporous mycelia. All the septa dividing the mycelia into cells were perfectly simple transverse walls (Pl. VI, Figs. 13, 14, 15).

Of *Coprinus curtus* eight mycelia were isolated, six monosporous in origin and two polysporous. All the cultures produced fruit-body rudiments. The rudiments in the two polysporous cultures developed to maturity and the expanded fruit-bodies shed spores, but in none of the six monosporous cultures did the rudiments develop to the stage of spore-production. However, two of the monosporous cultures were sub-cultured on dung in large crystallising dishes. Both of them then produced numerous perfect fruit-bodies. We can, therefore, state that in *Coprinus curtus*, under favourable conditions, the monosporous mycelia are able to develop normal fruit-bodies.

Of *Coprinus stellatus* only two cultures were made, one monosporous in origin and the other polysporous, both in dung tubes. The polysporous culture produced normal fruit-bodies and the monosporous culture only fruit-body rudiments.

Of *Coprinus cordisporus* only two cultures were made, one monosporous and the other polysporous, both in dung tubes. Both cultures produced fruit-body rudiments, but in neither culture did any of the rudiments develop into perfect fruit-bodies.

VIII. *Coprinus comatus.*

The fruit-body of *Coprinus comatus* Fr., as Buller* has pointed out, has a mechanism for the production and liberation of its spores practically identical with that of *C. sterquilinus*; and the two species are undoubtedly closely related. It was hoped, therefore, that as *C. sterquilinus* fruits so readily in monosporous cultures, this would also happen with *C. comatus*. Both monosporous and polysporous mycelia of *C. comatus* were therefore isolated and transferred to large masses of sterilised horse-dung contained in crystallising dishes; but none of them ever fruited. A mycelium derived from a stipe was transferred to a large mass of sterilised horse-dung contained in a three-litre beaker, and covered with three inches of soil. The mycelium was in the secondary condition, for its hyphae showed an abundance of clamp-connections. It grew well, invaded the whole mass of the dung, and penetrated through the soil; but, for some reason or other, it failed to fruit. In *Coprinus comatus*, therefore, the non-production of fruit-bodies in the laboratory is common to

* A. H. R. Buller, *loc. cit.* pp. 306, 324.

both monosporous and polysporous mycelia; and, for the present, one cannot say whether or not the fruiting power of the mycelium is affected by its monosporous or polysporous mode of origin.

Polysporous mycelia of *Coprinus comatus* develop an abundance of clamp-connections but no clamp-connections could be observed in two monosporous mycelia. These two monosporous mycelia were cultivated for 90 days in dung tubes. Then portions of the mycelia were removed from the tubes and placed on agar plates. The mycelia grew well on the plates, but none of their hyphae developed clamp-connections. On the other hand, a mycelium derived from a stipe and placed on an agar plate under the same conditions as the monosporous mycelia, developed an abundance of clamp-connections. These observations indicate that *Coprinus comatus* is probably a heterothallic species. However, before this conclusion can be accepted as having been proved, some further experiments upon the mycelia, especially crossings, ought to be undertaken.

IX. Summary of data.

The following table summarises data for the nine species of Coprinus treated of in the foregoing pages.

Summary of Data for Species of Coprinus

Species	Number of monosporous cultures made	Presence or absence of clamp-connections		Presence or absence of oidia	Homothallic or heterothallic
		in monosporous mycelia	in polysporous mycelia		
C. sterquilinus	21	+	+	–	Homothallic
C. lagopus	12	+	+	+	,,
C. stercorarius	6	+	+	–	,,
C. niveus	5	+	+	+	,,
C. ephemerus	2	?	+	+	Not determined
C. curtus	6	–	–	+	,,
C. stellatus	1	–	–	+	,,
C. cordisporus	1	–	–	+	,,
C. comatus	2	–	+	?	Heterothallic
Total ...	56				

X. Discussion.

From the facts communicated in the foregoing pages, there seems to be no doubt that *Coprinus sterquilinus*, *C. lagopus*, *C. stercorarius*, and *C. niveus* are all homothallic; while, on the other hand, *C. comatus* appears to be heterothallic. Mlle Bensaude found that her *C. fimetarius* is heterothallic. Hence it appears that, in the genus Coprinus, some species are homothallic and others heterothallic.

Mlle Bensaude found that her *Coprinus fimetarius* was sterile in monosporous cultures and fertile only in cultures containing a compound mycelium formed by the anastomosis of her mycelium *α* and her mycelium *β*, which she presumed as a result of her investigations to be of opposite sex. In view of Kniep's discovery that in a heterothallic species even unmated haploid mycelia produce fruit-bodies, it is perhaps remarkable that Mlle Bensaude's monosporous cultures did not fruit at all. It is desirable that this absence of fruiting powers in monosporous mycelia should be confirmed by the study of more monosporous mycelia than two. It is possible that some monosporous mycelia of her species could be caused to fruit by continuing and extending their cultivation. However, apart from the supposed criterion of fertility and sterility, Mlle Bensaude has presented us with evidence which seems to prove conclusively that her *Coprinus fimetarius* is heterothallic; for she found that clamp-connections and dicaryons were never formed in connection with the monosporous mycelia, while they were always formed in compound mycelia resulting from the mixture of her mycelium *α* and her mycelium *β*.

Brefeld* in recording his pioneer work on the life-histories of the Basidiomycetes, stated that he obtained fruit-bodies from mycelia produced from single spores for the following species: *Coprinus stercorarius*, *C. lagopus*, *C. ephemerus*, and *C. ephemeroides*. Mlle Bensaude† has raised the question as to whether or not Brefeld's mycelia were truly monosporous. The material for my investigation has included the first three of Brefeld's species, and for these species my results have been identical with his. Thus Mlle Bensaude's question has been answered in Brefeld's favour.

Mlle Bensaude, as a matter of theory, considers that the oidia produced on the mycelium of her *C. fimetarius* may be sex-carriers, *i.e.* that a + oidium may unite with a − mycelium and thus produce a fertile secondary mycelium bearing clamp-connections and fruit-bodies; and *vice versa*. However, as we have seen, both *Coprinus lagopus* and *C. niveus* are both homothallic and yet they produce oidia. It seems clear, therefore, that the oidia of these two species cannot be considered to act as sex-carriers, at any rate under present-day conditions, for the mycelium is homothallic and such sex-carriers, therefore, would be superfluous.

Miss M. L. Baden‡ stated in 1915 that the spores of *Coprinus*

* O. Brefeld, Untersuchungen, Leipzig, Heft III, 1877.

† M. Bensaude, *loc. cit.* p. 108.

‡ M. L. Baden, Observations on the Germination of Spores of *Coprinus sterquilinus* Fr., Ann. of Bot., XXIV, 1915, p. 141.

sterquilinus can only germinate in the presence of bacteria. In 1911, A. H. R. Buller and S. G. Churchward, working in the Botanical Department of the University of Manitoba, carried out a series of experiments upon the conditions of germination for the spores of *C. sterquilinus*; and they found that Miss Baden's conclusion was incorrect, for in their experiments 80 to 90 per cent. of the spores germinated in perfectly sterile hanging drops of various media*. I herewith state that my investigations entirely confirm the work of Buller and Churchward, for the spores of *C. sterquilinus* used in my cultures, when germinating, never came into contact with any bacteria. Were the presence of bacteria a necessary condition for the germination of the spores of *C. sterquilinus*, the isolation of monosporous mycelia could not have been accomplished by the simple methods which I actually employed. In none of the nine species of Coprinus with which I worked, is the presence of bacteria a necessary condition for the germination of the spores.

Miss E. M. Wakefield† made monosporous cultures of *Schizophyllum commune* and of *Stereum purpureum* and came to the conclusion that the chief factor making for sterility or fertility in her cultures was individual mycelial peculiarity, some mycelia fruiting readily and others refusing to fruit under any conditions. According to Kniep, the explanation of Miss Wakefield's results is as follows. *Schizophyllum commune* is a heterothallic species which fruits readily when the mycelium is diploid and has clamp-connections but more or less reluctantly when the mycelium is haploid and has no clamp-connections. On pairing the 14 monosporous mycelia which he isolated, he found that some pairs yielded clamp-connections and fruit-bodies and others not. In my work on Coprinus, I did not obtain a heterothallic species which fruited in artificial culture. However, it is remarkable that the homothallic species *Coprinus niveus* exhibited individual peculiarity in the fruiting of its monosporous mycelia, some mycelia having fruited readily, others having produced only fruit-body rudiments, and one having produced no rudiments at all. Yet even here, as already described, fruiting appeared to be stimulated by mixing two mycelia.

* A. H. R. Buller and S. G. Churchward in an unpublished paper shown me by Professor Buller. The delay in publication has been caused by Churchward going overseas to the war. The details of the work will be given in Professor Buller's second volume of "Researches on Fungi" now in preparation for the Press.

† E. M. Wakefield, Die Bedingungen der Fruchtkörperbildung bei Hymenomyceten, sowie das Auftreten fertiler und steriler Stämme bei denselben, Naturw. Zeitschr. f. Forst- und Landwirtschaft, VII, 1909, pp. 521–550.

XI. Conclusions.

1. *Coprinus sterquilinus*, *C. lagopus*, *C. stercorarius*, *C. niveus*, *C. ephemerus*, *C. curtus*, *C. stellatus*, and *C. cordisporus* all produced rudimentary fruit-bodies on a mycelium which originated from a single spore. In *C. sterquilinus*, *C. lagopus*, *C. stercorarius*, *C. niveus*, and *C. curtus*, these fruit-body rudiments developed into perfect fruit-bodies which shed ripe spores. In *C. ephemerus*, *C. stellatus* and *C. cordisporus*, under the conditions of culture employed, the fruit-body rudiments remained as such and never developed into perfect fruit-bodies.

2. Both monosporous and polysporous mycelia of *Coprinus comatus* failed to produce fruit-bodies in dung cultures.

3. Brefeld's statement that fruit-bodies of *Coprinus stercorarius*, *C. lagopus*, and *C. ephemerus* are produced on a mycelium which has developed from a single spore, has been confirmed.

4. As determined by clamp-connection criteria, *Coprinus sterquilinus*, *C. lagopus*, *C. stercorarius*, and *C. niveus* are homothallic, and *C. comatus* heterothallic.

5. *Coprinus curtus*, *C. stellatus*, and *C. cordisporous* do not produce any clamp-connections on any of their mycelia whether of monosporous or of polysporous origin. It was therefore found impossible to decide by clamp-connection criteria whether these three species are homothallic or heterothallic.

6. *Coprinus sterquilinus* was successfully cultivated in pure monosporous cultures for five successive generations. The mycelium of the fifth generation was just as vigorous and fruited just as rapidly as the mycelium of the first generation. The cultivation of *C. sterquilinus* from mycelia of monosporous origin does not, therefore, appear to weaken the fungus in any way.

7. The spores of *Coprinus sterquilinus* germinate freely in perfectly sterile potato agar and dung agar. Incidentally, therefore, I find myself in agreement with Buller and Churchward who, in a paper as yet unpublished, state that the spores of *C. sterquilinus* germinate readily without the presence of bacteria.

8. The monosporous mycelia of *Coprinus niveus* which is homothallic, exhibit a considerable range of variability in their fruiting powers, some producing perfect fruit-bodies, others only fruit-body rudiments, and yet others no rudiments at all. The mixing of the monosporous mycelia in pairs was found to stimulate fruiting in a marked manner.

9. Both monosporous and polysporous mycelia of *Coprinus lagopus*, when grown on large dung masses in crystallising

dishes, give rise to fruit-bodies some of which are perfect but others of which produce many spores which never ripen, a few ripe spores only, or no spores at all. Since this imperfection in spore-production is common to fruit-bodies produced by mycelia of both monosporous and polysporous origin, it cannot be due to sex.

10. Since *Coprinus lagopus* and *C. niveus* are both homothallic and yet produce oidia, Mlle Bensaude's interpretation of oidia as sex-carriers seems to be of doubtful value.

The investigations recorded above were made in the Botanical Department of the University of Manitoba during the tenure of a Studentship granted by the Canadian Honorary Advisory Council for Scientific and Industrial Research. In conclusion, I wish to express my indebtedness to Professor A. H. R. Buller for suggesting the investigation and for continuous help and encouragement during the progress of the work.

DESCRIPTION OF THE ILLUSTRATIONS.

Plate VI.

The magnification for Figures 1 and 2 is 510, and that for the remaining figures 480.

Fig. 1. *Coprinus sterquilinus*. A germinating spore after 17 hours in a potato decoction.

Fig. 2. *Coprinus sterquilinus*. Another germinating spore after 21 hours in a potato decoction.

Fig. 3. *Coprinus sterquilinus*. Two hyphae showing clamp-connections. From a compound mycelium of polysporous origin derived from the spores of a fruit-body of monosporous origin.

Fig. 4. *Coprinus sterquilinus*. A branched hypha showing one perfect clamp-connection and another clamp-connection in course of formation. From a monosporous mycelium of the fifth successive generation.

Fig. 5. *Coprinus lagopus*. A germinating spore after 18 hours in a dung-gelatine culture medium.

Figs. 6 and 7. *Coprinus lagopus*. Hyphae showing clamp-connections. Both from a monosporous mycelium derived from the spore of a wild fruit-body.

Fig. 8. *Coprinus lagopus*. A branched hypha showing a clamp-connection. From a compound mycelium of polysporous origin derived from the spores of a fruit-body of monosporous origin.

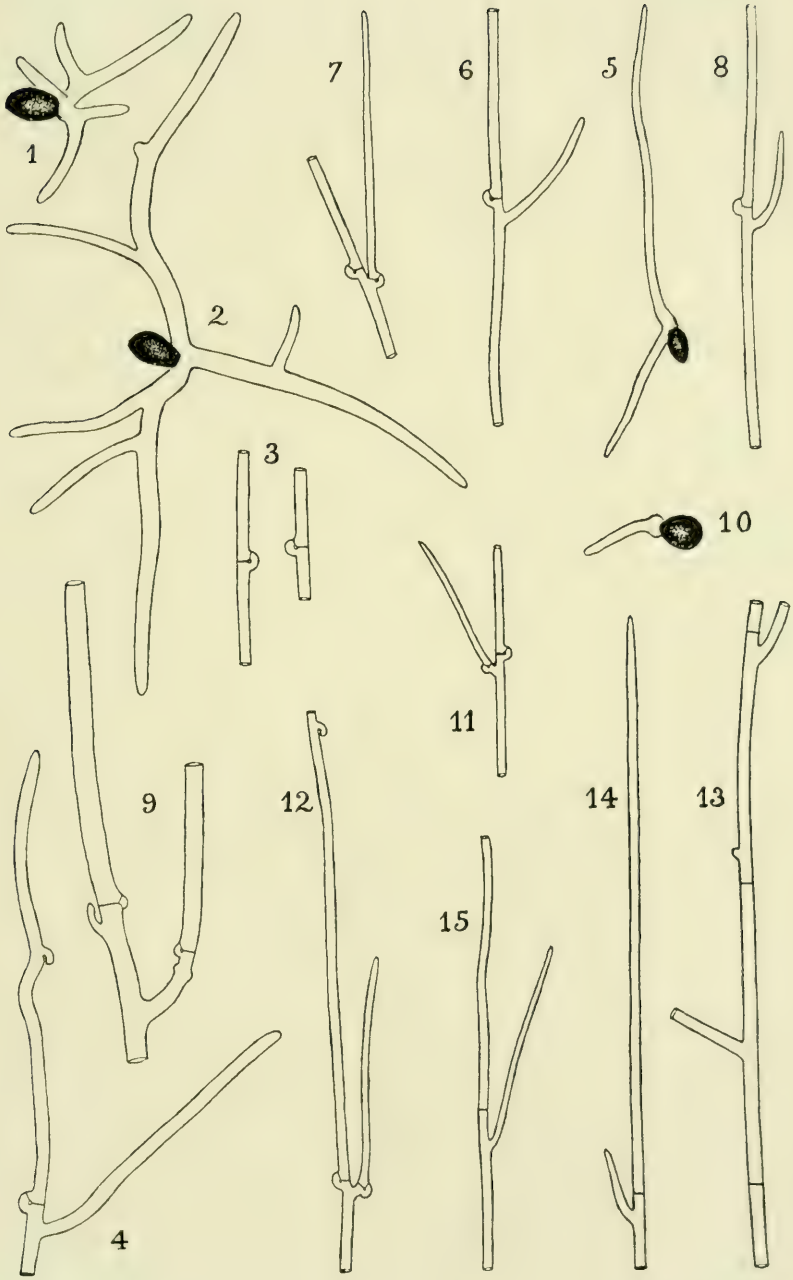
Fig. 9. *Coprinus stercorarius*. A branched hypha showing two small clamp-connections. From a compound mycelium of polysporous origin derived from the spores of a fruit-body of monosporous origin.

Fig. 10. *Coprinus niveus*. A germinating spore, taken from a fruit-body of monosporous origin, after 18 hours in dung-gelatine.

Fig. 11. *Coprinus niveus*. A branched hypha showing two clamp-connections. From a compound mycelium of polysporous origin derived from the spores of a fruit-body of monosporous origin.

Fig. 12. *Coprinus ephemerus* (a purplish form). A branched hypha showing two perfect clamp-connections and one clamp-connection in course of development. From a compound mycelium derived from the spores of a wild fruit-body.

Fig. 13. *Coprinus curtus*. A hypha showing three simple septa. From a monosporous mycelium derived from a spore of a wild fruit-body. The mycelium had been growing for 19 days.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

2

1

Fig. 14. *Coprinus stellatus*. A branched hypha showing a simple septum. From a compound mycelium of polysporous origin, the spores having been derived from a wild fruit-body.

Fig. 15. *Coprinus cordisporus*. A branched hypha showing a simple septum. From a compound mycelium of polysporous origin, the spores having been derived from a wild fruit-body.

PLATE VII.

Fig. 1. *Coprinus sterquilinus*. Two horse-dung cultures from which fruit-bodies have been developed, made simultaneously. The cotton-wool plugs were removed 48 hours ago to allow the fruit-bodies to elongate without being injured. The culture tube on the left contains a mycelium of monosporous origin. This mycelium has just given rise to its first fruit-body with its spores which completes the last of a series of five successive generations of monosporous cultures. The culture tube on the right contains a compound mycelium of polysporous origin derived from spores of the same fruit-body as that which provided the spore for the culture already described. This compound mycelium has given rise to a fruit-body which expanded, shed spores, and exhausted itself on the day before the photograph was taken. Seven-tenths natural size.

Fig. 2. *Coprinus lagopus*. Photograph of a group of fruit-bodies which has come up on sterilised horse-dung contained in a large crystallising dish. The mycelium was of monosporous origin and the original spore was derived from a wild fruit-body. The mycelium was transferred to the culture medium only 12 days before the photograph was taken. The pilei are covered with characteristic loose white scales and are ripening their spores in preparation for the elongation of the stipes and pilear expansion. Natural size.

NOTES.

LONGEVITY OF SPORES OF A FUNGUS IN A MUSEUM SPECIMEN.

For comparison with a fungus which had been isolated from and proved to be the cause of black spots on leather, a small portion of a piece of the bark of a lime tree covered with a black sooty deposit, was given to me from the Herbarium of the British Museum (Natural History) in June of this year.

The specimen was from the Rabenhorst-Klotschii, Herbarium vivum Mycologicum, Editio II, Series I, No. 75, and was described as *Cladosporium fumago* Lk. It had been obtained from Sächs, Switzerland, in the summer of 1854. The cabinets in which the specimen had been kept in the Museum are saturated with camphor. Small portions of the bark were placed on slopes of Beer Wort Agar, Czapek's and other media and incubated for some days without showing any signs of life. A piece placed in a tube of sterile Beer Wort also showed no signs of growth.

The following technique was however successful:

A tube of sterile Beer Wort was kept in a slanting position, a small piece of the bark was introduced, dipped under the

surface of the liquid by means of a sterile platinum wire loop, and withdrawn on to the side of the glass tube, where it was left exposed to the air inside the tube for 24 hours. It was then dipped under the surface of the wort, and again withdrawn and left for 24 hours, the tube being incubated at 25° C. in the sloping position. This treatment was continued for five days, the piece of bark being dipped and withdrawn every morning.

At the end of this time signs of growth began to appear, and by the seventh day, sufficient mycelium had formed to enable sub-cultures to be made.

The fungus then grew quite readily on ordinary Beer Wort Agar or Czapek's medium, and was easily identified as *Fumago vagans* Pers. (= *Cladosporium fumago* Lk.).

During the cultivation process, no other organism made its appearance.

This seems to be of interest as a case of the persistance of life in the spores or mycelium of a Hyphomycete kept as a museum specimen for 67 years.

R. LESLIE COLLETT,
(British Leather Manufacturers' Research Association).

ERROR IN BOUDIER'S MICROMETRIC MEASUREMENTS.

Monsieur René Maire makes the following very important statement regarding Boudier's measurements of spores in the Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord, VIII, no. 9 (Dec. 1917), 247: "Les mensurations de Boudier étant d'ordinaire trop fortes d'1/10 environ, par suite d'une erreur dans la confection de son échelle micrométrique."

CARLETON REA.

Published the 13th December, 1921.

REVIEW.

A Handbook of the British Lichens, by ANNIE LORRAIN SMITH. 8vo. 158 pp. with 90 figs. in the text. 6*s*. cloth. London. Printed by order of the Trustees of the British Museum.

To students of Bryology the identification of specimens is made easy by the keys given in the excellent works of Dixon and Macvicar. In the *Monograph of the British Lichens* by Miss Lorrain Smith no such keys are given and much difficulty is encountered by a beginner in running down a species in large genera such as Lecanora and Lecidea. This deficiency (if such it can be considered in a monograph) has now been remedied by the publication of the present *Handbook*. The author has placed lichenologists of all classes under further obligation by producing a condensed volume which can easily be carried in the pocket.

There is an introduction of thirteen pages (with many illustrations) giving a short account of the lichen plant and dealing with such matters as constitution, morphology, peculiar vegetative structures, reproductive organs, physiology, ecology and distribution, economic uses, phylogeny and classification. This is followed by a list of abbreviations used in the descriptions. In the body of the work the arrangement down to the families is like that in the author's larger book. Following the description of the family there is a key to the genera. The keys are not of a dichotomous type but of the group type, one much to be preferred in that it ensures that genera (and species) of close affinity do not get widely separated. The genera are described and in the majority of cases a drawing is given mostly from the plates in the *Monograph*. In the keys to the species the grouping is made on prominent characters of habit, habitat or growth form and in most of the smaller genera the morphological characters are sufficient for an identification in the field: in the larger genera recourse often has to be had to reactions and microscopic characters. There is a glossary and a workable index. The *Handbook* is invaluable for what it sets out to be—a key to the British species and a portable guide.

H. H. K.

PROCEEDINGS, 1921.

MEETING. UNIVERSITY COLLEGE, LONDON. *Jan. 22nd.*

Mr F. T. Brooks. Investigations on some tomato fruit diseases.
Dr E. J. Butler. The Imperial Bureau of Mycology.
Miss G. Lister. A new genus of Mycetozoa.
Mr T. Petch. Thread Blights.
Mr J. Ramsbottom. Orchid culture.

MEETING. UNIVERSITY COLLEGE, LONDON. *March 19th.*

Dr R. St John Brooks. National Collection of Type Cultures.
Dr W. Brown. Studies in the physiology of parasitism.
Mr A. D. Cotton. The Ministry of Agriculture's plant disease survey.
Dr P. Haas. Carrageen as a culture medium.
Dr A. S. Horne. A pleomorphic Aposphaeria.
Mr R. Paulson. *Protococcus* as the gonidium of a Lichen.
Miss A. Lorrain Smith. The lichen as transmigrant.

The whole of the first part of the British Mycological Society's Transactions (Season 1896–1897) has now been sold.

The other parts may be purchased at the following prices:—

Vol. I.

Season 1897-1898	at . .	5/6
1898-1899	at . .	5/6
1899-1900	at . .	7/6
1900-1901	at . .	11/6

Vol. II.

1902	at . .	11/6
1903	at . .	11/6
1904	at . .	15/-
1905	at . .	15/-
1906	at . .	15/-

Vol. III.

1907	at . .	15/-
1908	at . .	16/-
1909	at . .	16/-
1910	at . .	16/-
1911	at . .	16/-

Vol. IV.

1912	at . .	16/-
1913	at . .	16/-

Vol. V.

1914	at . .	16/-
1915	at . .	16/-
1916	at . .	16/-

Vol. VI.

1917	at . .	16/-
1918	at . .	16/-
1919	Pt III at .	8/-
1919	Pt IV at .	10/6

Vol. VII.

1920	Pts I & II at	12/6

All applications respecting past Transactions should be made to the Treasurer.

CONTENTS

PAGE

Studies in Entomogenous Fungi (cont.). By T. Petch, B.A., B.Sc. 133

The Imperial Bureau of Mycology. By E. J. Butler, C.I.E., D.Sc., M.B., F.L.S. 168

An Investigation of Some Tomato Diseases. By F. T. Brooks, M.A. and G. O. Searle, B.Sc. 173

Homothallism and the Production of Fruit-Bodies by Monosporous Mycelia in the Genus Coprinus. By Miss Irene Mounce, M.A. (British Columbia) . . 198

Notes. Longevity of Spores of a Fungus in a Museum Specimen. R. Leslie Collett. 217

Error in Boudier's micrometric measurements. Carleton Rea 218

Review 219

PRINTED IN ENGLAND BY J. B. PEACE, M.A. AT THE CAMBRIDGE UNIVERSITY PRESS

VOL. VII, PART IV. *Published July* 21, 1922

The British Mycological Society

(*Recognosce notum, ignotum inspice*)

TRANSACTIONS 1920

Edited by

CARLETON REA and J. RAMSBOTTOM

Price to non-members, 12/6

CAMBRIDGE
AT THE UNIVERSITY PRESS
1922

LIST OF OFFICERS AND COUNCIL FOR 1921

Elected September 1920

President

CARLETON REA, B.C.L., M.A., Hon. memb. Brit. Myc. Socy, etc.

Vice-Presidents

Miss GULIELMA LISTER, F.L.S., T. PETCH, B.A., B.Sc.

Treasurer and Foray Secretary

A. A. PEARSON, F.L.S.
59, Southwark Street, London, S.E. 1.

General Secretary

J. RAMSBOTTOM, M.A., F.L.S., O.B.E.
British Museum (Nat. Hist.), Cromwell Road, London, S.W. 7.

Secretary

Miss E. M. WAKEFIELD, M.A., F.L.S.
The Herbarium, Royal Botanical Gardens, Kew, Surrey.

Editors

CARLETON REA, B.C.L., M.A.
and
J. RAMSBOTTOM, M.A., F.L.S., O.B.E.

COUNCIL

The OFFICERS, with the following in addition:

W. B. ALLEN, Prof. R. H. BIFFEN, F. T. BROOKS, Prof. A. H. R. BULLER, Miss D. M. CAYLEY, A. D. COTTON, Very Rev. D. PAUL, T. PETCH, Prof. M. C. POTTER, Mrs E. A. REA, Miss A. LORRAIN SMITH, E. W. SWANTON, and H. WAGER.

SUB-COMMITTEE FOR PLANT PATHOLOGY

F. T. BROOKS, M.A. (*Chairman*)
E. J. BUTLER, C.I.E., D.Sc.
A. D. COTTON, F.L.S. (*Secretary*)
T. PETCH, B.A., B.Sc.
G. H. PETHYBRIDGE, B.Sc., Ph.D.
J. RAMSBOTTOM, M.A., F.L.S.

The President and Secretary of the Society *ex Officio*.

HASLEMERE, SPRING FORAY.

May 13th–16th, 1921.

The spring foray was held at Haslemere, Surrey, during the Whitsuntide Holidays, at the invitation of the Haslemere Natural History Society. About thirty members assembled at the Educational Museum on Friday evening and were received by Mr and Mrs E. W. Swanton and members of the Haslemere Natural History Society. On Saturday morning a start was made from the Museum at 10 o'clock by motor for Verdly woods, Sussex. As was to be expected in consequence of the previous drought very few of the larger fungi were to be found and it cannot be said that the microforms were very abundant. The stroll through the beech woods was enlivened by the visible emission of spores from fruit bodies of *Ganoderma applanatum*. These were on a fallen log on a steep slope and as the ascent was made with the sporophores between the sun and the climbers the spore discharge was remarkably clear.

Sunday morning was left open, but many of the party climbed Blackdown with little or no mycological results. In the afternoon the members left the Museum at 2.30 and visited Valewood Park and woods. A number of species were added of which *Puccinia Epilobii* was perhaps the most interesting. The party was entertained to tea by Mrs Daffarn.

On Monday, after the members had been photographed, a start was made for Blackdown Park. Fungi again were scarce and the day seemed blank for interesting finds, but as the grounds of the house were approached to have tea at the invitation of Lady Philipson-Stow a number of polypores were noticed on the boles of *Abies pectinata*. Some of these were afterwards secured and proved to be *Fomes robustus**, a fungus not previously recorded for this country.

The evenings were spent at the Museum examining the specimens gathered and taking advantage of the mycological exhibits arranged by Mr Swanton to whom the Foray owed its success.

A vote of thanks was awarded to Major the Hon. Harold Pearson for permission to visit Verdly woods and to Mrs Daffarn and Lady Philipson-Stow for their permits and hospitality.

In preparing the following list of species the writer is indebted to the various members of the party for records of their finds, particularly to Mr A. A. Pearson and Mr E. W. Swanton.

* For description see British Basidiomycetae by Carleton Rea, p. 593.

H = Haslemere. *V* = Verdly Woods. *P* = Valewood Park. *B* = Blackdown Park.

HYMENOMYCETES.

Lepiota amianthina (Scop.) Fr. *V.*
Armillaria mellea (rhizomorphs) (Vahl.) Fr. *P.*
Tricholoma flavobrunneum Fr. *V.*, terreum (Schaeff.) Fr. *V.*, gambosum Fr. *H.B.*
Clitocybe phyllophila Fr. *V.*, fragrans (Sow.) Fr. *B.*
Collybia maculata (A. & S.) Fr. *B.*, conigena (Pers.) Bres. *P.B.*
Mycena haematopus (Pers.) Fr. *B.*, polygramma (Bull.) Fr. *B.*, stylobates (Pers.) Fr. *B.*
Omphalia umbellifera (Linn.) Fr. *P.*
Nolanea pascua (Pers.) Fr. *V.P.B.*, proletaria Fr. *V.*
Claudopus variabilis (Pers.) W. G. Sm. *B.*
Pholiota praecox (Pers.) Fr. *P.B.*
Naucoria Cucumis (Pers.) Fr. *P.*
Galera hypnorum (Schrank) Fr. *V.B.*
Stropharia semiglobata (Batsch.) Fr. *P.*, merdaria Fr. *B.*, coronilla (Bull.) Fr. *V.*
Hypholoma fasciculare (Huds.) Fr. *V.*, Candolleanum Fr. *P.*
Psilocybe ericaea (Pers.) Fr. *V.*
Psathyra fibrillosa (Pers.) Fr. *P.*, pennata Fr. *H.*
Panaeolus campanulatus (Linn.) Fr. *V.P.B.*
Psathyrella gracilis Fr. *V.*, atomata Fr. *B.*, disseminata (Pers.) Fr. *B.*
Coprinus cinereus (Schaeff) Cke. *V.*, radiatus (Bolt.) Fr. *B.*, plicatilis (Curt.) Fr. *V.B.*
Cortinarius hinnuleus (Sow.) Fr. *V.*, leucopus (Bull.) Fr. *V.*
Cantharellus cibarius Fr. *P.*
Panus stypticus (Bull.) Fr. *H.V.*
Lenzites betulina (Linn.) Fr. *P.*
Boletus flavus With. *V.*
Polyporus Schweinitzii Fr. *P.*, amorphus Fr. *P.*, nummularis (Bull.) Quél. *B.*, sulphureus (Bull.) Fr. *P.*, chioneus Fr. *B.*, adustus (Willd.) Fr. *V.*, betulinus (Schrad.) Fr. *V.P.B.*
Ganoderma applanatum (Pers.) Pat. *V.*
*Fomes robustus Karst. *B.*, annosus Fr. *P.*, ferruginosus (Schrad.) Mass. *P.*
Polystictus versicolor (Linn.) Fr. *V.P.B.*, abietinus (Dicks.) Fr. *P.*
Poria viridans Berk. *P.*
Trametes gibbosa (Pers.) Fr. *V.P.*
Daedalea quercina (Linn.) Fr. *V.*
Merulius corium (Pers.) Fr. *P.*
Irpex obliqua (Schrad.) Fr. *V.P.B.*
Stereum hirsutum (Willd.) Fr. *V.P.B.*, rugosum (Pers.) Fr. *P.*
Hymenochaete rubiginosa (Dicks.) Lév. *V.*
Corticium arachnoideum Berk. *V.*, subcoronatum v. Hoehn. & Litsch. lividum (Pers.) Fr. *B.*, (Gloeocystidium) praetermissum (Karst.) Bres. *V.*
Peniophora cremea Bres. *P.*, Aegerita v. Hoehn. & Litsch. *V.*, velutina (DC.) Cke. *P.*, Molleriana (Bres.) Sacc., hydnoides Cke. & Mass. *V.P.*
Hypochnus fumosus Fr. *P.*
Dacryomyces deliquescens (Bull.) Duby *V.*
Lycoperdon pyriforme (Schaeff.) Pers. *B.*, depressum Bon. *B.*, caelatum (Bull.) Fr. *B.*
Exidia glandulosa (Bull.) Fr. *V.*
Bovista plumbea Fr. *B.*, nigrescens Pers. *B.*
Scleroderma verrucosum (Vaill.) Pers. *V.*
Cyathus striatus (Huds.) Pers. *V.*

* *New British Record.*

UREDINEAE.

Uromyces flectens Lagerh. on *Trifolium repens H.*, Ervi (Wallr.) Westend. on *Vicia hirsuta B.*, Ficariae (Schum.) Lév. on *Ranunculus Ficaria B.*, Acetosae Schroet. *V.*, Scillarum (Grev.) Wint. on *Scilla nonscripta V.*, Dactylidis Otth. *H.*, Poae Rabenh. aecidia on *Ranunculus repens H.*

Puccinia obtegens (Link) Tul. *H.*, Hypochaeridis Oud. *H.*, Taraxaci Plowr. *H.*, Menthae Pers. on *Mentha aquatica V.B.*, Betonicae (A. & S.) DC. *B.*, Primulae (DC.) Duby *V.B.*, Saniculae Grev. *V.*, tumida Grev. on *Carum maius H.*, Epilobii DC. on *Epilobium palustre P.*, pulverulenta Grev. *P.*, Violae (Schum.) DC. on *Viola canina V.P.*, fusca (Relh.) Wint. *B.*, obscura Schroet. on *Luzula sylvatica V.*, Caricis (Schum.) Rebent. aecidia on *Urtica H.*, graminis Pers. on *Poa H.*

Phragmidium Rubi (Pers.) Wint., mucronatum (Pers.) Schlecht. *V.*

Coleosporium Senecionis (Pers.) Fr. *V.*

Pucciniastrum pustulatum (Pers.) Diet. on *Epilobium angustifolium P.*

Melampsora Hypericorum (DC.) Schroet. on *Hypericum Androsaemum V.*

Thecopsora Vacciniorum (Link) Karst. *V.*

USTILAGINEAE.

Tilletia debaryana Fisch. v. Waldh. on *Holcus mollis H.P.*

Urocystis Anemones (Pers.) Wint. *B.*, Violae (Sow.) Fisch. v. Waldh. *V.B.*

DISCOMYCETES.

Aleuria vesciculosa (Bull.) Boud. *V.*

Ciliaria scutellata (Linn.) Quél. *V.*

Coprobia granulata (Bull.) Boud. *V.*

Ascobolus glaber Pers. *B.V.*, furfuraceus Pers. *V.B.*, vinosus Berk. *B.*

Dasyobolus immersus (Pers.) Sacc. *B.*

Saccobolus violascens Boud. *V.*

Ascophanus carneus (Pers.) Boud. *V.B.*, lacteus (Cooke & Phill.) Phill. *V.*

Lasiobolus equinus (Mull.) Karst. *V.*

Rhyparobius brunneus Boud. *B.*

Coryne sarcoides (Jacq.) Tul. *B*

Bulgaria inquinans (Pers.) Fr. *V.*

Polydesmia pruinosa (B. & Br.) Boud. *V.*

Orbilia xanthostigma Fr. *V.P.B.*

Sclerotinia Curreyana (Berk.) Karst. (sclerotia) *P.*

Chlorosplenium aeruginosum (Oeder.) de Not. *V.B.*

Helotium herbarum (Pers.) Fr. *B.V.P.*, virgultorum (Wahl.) Karst. *B.*

Dasyscypha virginea (Batsch.) Fuck. *V.*, nivea (Hedw. f.) Sacc. *P.*

Trichoscypha calycina (Schum.) Boud. *V.*

Hyaloscypha hyalina (Pers.) Boud. *V.B.*

Mollisia cinerea (Batsch.) Karst. *V.B.*

Stegia Ilicis Fr. *V.P.B.*

Pseudopeziza Trifolii (Biv. Bern.) Fuck. *B.*

Rhytisma acerinum (Pers.) Fr. *P.*

PYRENOMYCETES.

Sphaerotheca pannosa Lév. *V.*

Erysiphe cichoracearum DC. *V.*, Polygoni DC. *B.*

Uncinula Aceris (DC.) Sacc. *B.*

Eurotium herbariorum (Wigg.) Link *H.*

Nectria cinnabarina (Tode) Fr. *V.P.*, coccinea (Pers.) Fr. *V.B.*, episphaeria (Tode) Fr. on *Diatrype V.*, Peziza (Tode) Fr. *V.*

Hypomyces rosellus (A. & S.) Tul. *V.B.*, aurantius (Pers.) Tul. *V*

Hypocrea fungicola Karst. on *Polyporus betulinus P.*

Epichloe typhina (Pers.) Tul. on *Holcus, H.*

Sordaria fimicola (Rob.) Ces. & de Not. *V.B.*

Podospora coprophila (Fr.) Wint. *B.*

Sporormia fimetaria de Not. *V.*

Leptospora ovina (Pers.) Fuck. *V.B.*
Bertia moriformis (Tode) de Not. *P.*
Stigmatea Robertiani Fr. *B.*
Sphaerella Pteridis (Desm.) de Not. *V.B.*, maculiformis (Pers.) Auersw. *H.*, hedericola (Desm.) Cooke *V.*
Leptosphaeria Rusci (Wallr.) Sacc. *V.*
Diatrypella quercina (Pers.) Nits. *V.*
Diatrype Stigma (Hoff.) de Not. *B.*, disciformis (Hoffm.) Fr. *B.*
Hypoxylon multiforme Fr. *V.B.*, rubiginosum (Pers.) Fr. *B.*, fuscum (Pers.) Fr. *V.*, coccineum Bull. *V.B.*
Ustulina vulgaris Tul.
Xylaria hypoxylon (Linn.) Grev. *V.P.B.*, polymorpha (Pers.) Grev. *V.B.*
Phyllachora graminis (Pers.) Fuck. *B.*, Junci Fuck. *B.*

PHYCOMYCETES.

Mucor Mucedo (Linn.) Bref. *H.*, racemosus Fres.
Spinellus fusiger (Link) van Tiegh. *V.*
Rhizopus nigricans Ehrenb. *V.*
Pilaira anomala (Ces.) Schroet. *B.*
Pilobolus crystallinus (Wigg.) Tode *B.*
Piptocephalus Fresiana de Bary *V.B.*
Cystopus candidus (Pers.) Lév. *V.*
Plasmopara nivea (Ung.) Schroet. *P.*
Peronospora Myosotidis de Bary *B.*, Ficariae Tul. *B.*, grisea Ung. on *Veronica Beccabunga H.*

HYPHOMYCETES.

Ovularia obliqua (Cke.) Oud. *V.P.B.*, primulana Karst. *V.*
Oidium alphitoides Griff. & Maubl. *V.*
Isaria farinosa (Dicks.) Fr. *V.B.*
Acrostalagmus cinnabarinus Cord. *P.*
Trichothecium roseum Fr.
Stysanus Stemonitis (Pers.) Cord. *B.*
Aegerita candida (Pers.) Grev. *V.*
Ramularia Calthae (Cke.) Liro *B.*, Geranii (West.) Fuck. *H.*, variabilis Fuck. *H.*, Taraxaci Karst. *H.B.*

SPHAEROPSIDEAE.

Phyllosticta hedericola Dur. & Mont. *V.*, Mahoniana (Sacc.) Allesch. *V.*, Cirsii Desm. *B.*
Diplodia Crataegi West. *V.*
Phoma conigena Karst. (Discella strobilina (Desm.) Died.) *V.P.*, Crataegi Sacc. *V.*, samarorum Desm. *B.*, aculeorum Sacc. *V.P.B.*, Urticae Schultz & Sacc. *V.*
Leptothyrium Castaneae (Spr.) Sacc. on *Castanea V.*, var. Quercus C. Massal. on *Quercus V.P.B.*
Septoria Anemones Desm. *B.*, Bellidis Desm. & Rob. *H.V.*, Ficariae Desm. *B.*, graminum Desm. *H.*, Hederae Desm. *V.B.*, Ribis Desm. *V.*, Rubi West. *V.P.B.*

MYXOMYCETES. (H. J. Howard.)

Ceratiomyxa fruticulosa Macbr.
Physarum nutans Pers. var. leucophaeum Lister, sinuosum Weinm
Craterium minutum Fr.
Leocarpus fragilis Rost.
Didymium difforme Duby, squamulosum Fr.
Stemonitis fusca Roth.
Comatricha nigra Schroet.
Reticularia Lycoperdon Bull.
Lycogala epidendrum Fr.
Trichia affinis de Bary, persimilis Karst., botrytis Pers.
Arcyria pomiformis Rost., denudata Sheld., incarnata Pers.

LICHENS OF HASLEMERE DISTRICT.

By H. H. Knight, M.A.

Most of the lichens in this list were found growing on trees or palings. There are no exposed rocks in the neighbourhood of Haslemere, and the few saxicolous species were seen on stone walls near farm-houses. A few of these lichens were seen on Hindhead, the majority come from the Sussex woods visited during the meeting.

Chaenotheca melanophaea Zwackh.
Calicium curtum Turn. & Borr.
Collema cheileum Ach.
Leptogium tenuissimum Koerb.
Peltigera canina Willd.
Parmelia physodes Ach.
P. perlata Ach.
P. caperata Ach.
P. saxatilis Ach., form furfuracea Schaer.
P. sulcata Tayl.
P. fuliginosa Nyl. var. laetevirens Nyl.
Cetraria aculeata Fr.
Evernia prunastri Ach.
Usnea florida Web., var. hirta Ach.
U. plicata Web.
Xanthoria parietina Th. Fr.
X. polycarpa Oliv.
X. lychnea Th. Fr.
Physcia hispida Tuckerm.
Lecanora muralis Schaer.
L. subfusca Ach, var. chlarona Ach.
L. atra Ach.
L. galactina Ach.
L. varia Ach.
L. conizaea Nyl.
L. symmictera Nyl.
L. sulphurea Ach.
L. parella Ach.
Pertusaria faginea Leight.
P. pertusa Dal. Tor. & Sarnth.
P. leioplaca Schaer.
P. Wulfenii DC.
Diploschistes scruposus Norm.
Baeomyces rufus DC.
Cladonia sylvatica Hoffm.
C. pyxidata Hoffm.
C. fimbriata Fr.
C. squamosa Hoffm.
C. Floerkeana Fr.
Lecidea ostreata Schaer.
L. granulosa Schaer.
L. uliginosa Ach.
L. fuliginea Ach.
L. parasema Ach.
L. latypea Ach.
L. crustulata Koerb.
L. sylvicola var. infidula Cromb.
Biatorina Griffithii Massal.
B. synothea Koerb.
Bacidia atrogrisea Arn.
Buellia myriocarpa Mudd.
Rhizocarpum confervoides DC.
Arthonia radiata var. Swartziana Sydow.
Opegrapha herpetica Ach.
O. atra Pers.
O. betulina Sm.
O. vulgata Ach.
Graphis elegans Ach.
G. scripta Ach.
Phaeographis inusta Muell.-Arg.
P. dendritica Muell.-Arg.
Enterographa crassa Fée.
Acrocordia gemmata Koerb.
Arthopyrenia fallax Arn.
Porina carpinea A. Zahlbr.
Pyrenula nitida Ach.

THE BASIDIAL AND OIDIAL FRUIT-BODIES OF DACRYOMYCES DELIQUESCENS.

By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.

Dacryomyces deliquescens is a very common fungus in England and appears during wet weather upon the surface of dead wood, such as old logs, rails, garden seats, gate-posts, etc.; but it was imperfectly described by the older systematists and by Massee, and its true nature is still misunderstood by many field mycologists. Tulasne* studied its life-history and made the discovery (since confirmed by Brefeld†) that it produces two kinds of fruit-bodies which can be readily distinguished with the naked eye owing to colour differences: (1) orange fruit-bodies, and (2) pale yellow fruit-bodies. Both are gelatinous. The orange fruit-bodies produce oidia and the yellow fruit-bodies basidiospores. The orange fruit-bodies were originally described as *Dacryomyces stillatus* Nees and the yellow fruit-bodies as *Dacryomyces deliquescens* Duby; and this erroneous division of one species into two is still generally retained in systematic hand-books. To clear up the confusion which has thus arisen, I shall now re-describe *Dacryomyces deliquescens* from my own observations.

The orange fruit-bodies are small, rounded or hemispherical, 1–4 mm. in diameter and 1–2 mm. high, occurring in groups of more or less isolated individuals in lines along the grain of the woody substratum and often on its upper side so that they attract the eye. The yellow fruit-bodies are about the same size as the red ones, rounded, hemispherical or discoid, often somewhat wrinkled into folds at the surface especially where two or more fruit-bodies have anastomosed during development, and occurring like the red fruit-bodies in groups of more or less isolated individuals in lines along the grain of the woody substratum and often on its upper surface. In dry weather both the orange and the pale yellow fruit-bodies shrink very greatly, owing to loss of water, and become quite inconspicuous and difficult to find. When rain comes again, the fruit-bodies rapidly absorb water by imbibition and regain their former size and colour. There are few other fruit-bodies so dependent on atmospheric conditions as these.

In nature, the orange fruit-bodies often appear on the surface of wood in groups by themselves. The yellow fruit-bodies also

* L. R. Tulasne, Observations sur l'organisation des Trémellinées, Ann. des sci. nat., Bot., t. XIX, 1853, p. 211.

† O Brefeld, Untersuchungen, Leipzig, 1888, pp. 141–152.

often appear on the surface of wood in groups by themselves. Sometimes, however, patches of red and patches of yellow fruit-bodies appear near to one another on the same piece of wood but not intermingled; and, finally, sometimes red and yellow fruit-bodies appear on wood intermingled promiscuously. According to Tulasne, yellow fruit-bodies may be found, which have red spots upon them or which are gradually changing into red fruit-bodies*. The reason for these variations in the distribution of the two kinds of fruit-body under natural conditions is not yet understood, but the production of one kind of fruit-body rather than another doubtless depends on the physiological condition—possibly the nuclear state—of the underlying mycelium†.

An orange fruit-body has a gelatinous matrix derived from the swollen outer confluent hyphal walls, and this matrix, while firm toward its centre, is more and more readily deliquescent in wet weather as one passes toward its periphery. A fruit-body consists of two parts—an inner, firmer, paler core attached to the substratum, and an outer, more softly gelatinous, thick, bright orange, exterior coating. The core contains pale, thin, branched, anastomosing hyphae which run toward the periphery of the fruit-body and there thicken and give rise to branched chains of pale orange oidia. Thus the thick orange outer coating of the fruit-body comes to be made up of oidia which are embedded in very soft jelly, and its colour is entirely due to the colour of the oidia. The oidia consist of one or two cells and show all stages of detachment from one another. Those on the very exterior of the fruit-body sometimes produce tiny conidia which project into the air. When rain comes, the outer part of the orange oidial zone deliquesces, i.e. the jelly absorbs so much water that it becomes liquid and flows. Thus during rain a large number of the outer oidia are washed away from the fruit-body and become dispersed. However, the production of oidia by the hyphae of the core is long continued so that new oidia gradually take the place of those previously washed away. It thus appears that the orange fruit-bodies are specialised for producing oidia and do not as a rule give rise to any basidiospores.

A yellow fruit-body, like a red one, has a soft gelatinous matrix derived from the swollen outer confluent hyphal walls. This matrix contains and envelops slender, branching, anastomosing hyphae which, toward the periphery of the fruit-body, branch and re-branch to produce the basidia which make up the

* L. R. Tulasne, *loc. cit.*, pp. 216–218, Pl. 13, fig. 2.

† Cf. P. A. Dangeard, Mémoire sur la reproduction sexuelle des Basidiomycètes, Le Botaniste, t. IV, 1895, pp. 136–143.

hymenium. Each basidium has a body which is slender and cylindrical and which develops at its apex two stout divergent arms or sterigmata, the tips of which come to penetrate through the surface of the gelatinous matrix. Each sterigma produces at its free tip a single, elongated, curved spore which is provided with a well-marked hilum. The time taken for a spore to develop from a just recognisable rudiment to full size is only about 23 minutes. After a further 27 minutes the spore is discharged. Thus about 50 minutes only are taken up in the development, ripening, and discharge of each spore. There can be little doubt that this rapid rate of coming to maturity for each individual spore is a factor in assisting a revived fruit-body in rapidly resuming its spore-discharging function after rain. The drop excreted at the hilum begins to appear about 16 seconds before the spore is discharged, grows until it attains the diameter of the spore, and is then carried away by the spore when this is shot from its sterigma. A spore can be shot out from its sterigma 0·5–0·65 mm., so that although the hymenium often looks upwards, the wind has an opportunity of carrying away the spores before they can fall back on the hymenium.

Massee*, in his "British Fungus-Flora," describes the yellow fruit-bodies of *Dacryomyces deliquescens* as follows:

"*Dacryomyces deliquescens* Duby.

Gelatinous, rounded or irregular, convex, gyrose, yellow, hyaline, basal portion root-like and entering the matrix, spores cylindrical, obtuse, curved, 3-septate, 15–17 × 6–7 μ.

Dacryomyces deliquescens. Duby, Bot. Gall., p. 729; Cke., Hdbk., p. 351.

On pine-wood. In perfection during the winter months. Forming yellow subcircular convex masses 1–4 lines broad, often growing in long lines out of cracks in the wood."

Massee's statement that the spores are 3-septate is misleading. The fact is that the spores, when on their sterigmata and immediately after discharge, are *unicellular* just like those of other Tremellineae, and only become 3-septate and 4-celled when lying in water and preparing to germinate. The spores of several other Tremellineae behave similarly†.

Massee says that the fruit-bodies occur on pine-wood. That is true, but my experience is that they occur on various kinds

* G. Massee, British Fungus-Flora, London, 1892, vol. 1, p. 67.

† In his illustration of a basidium of *Dacryopsis nuda* Mass. in his British Fungus-Flora (vol. 1, p. 56), Massee represents the spores on the sterigmata as 3-septate and 4-celled. It is not unlikely that this is an error and that the spores on the sterigmata should have been represented as unicellular. Massee may have found isolated spores lying on the hymenium which had become 3-septate after discharge and have then supposed that they were 3-septate before discharge.

of wood both hard and soft, but especially on coniferous woods. Massee says that the fruit-bodies are 1–4 lines wide. These measurements seem to me a little too large. As Massee says, the fruit-bodies are yellow. However, I find that the fruit-bodies most exposed to the light are the yellowest, and that those which grow under logs and boards and in other very dark situations are relatively very pale yellow and sometimes almost colourless.

Massee*, in his "British Fungus-Flora," describes the red fruit-bodies of *Dacryomyces deliquescens* as follows:

"*Dacryomyces stillatus* Nees.

Gelatinous, rounded, convex, more or less plicate, persistently orange; spores cylindrical, curved, and multiseptate, 18–22 × 7–8 μ.

Dacryomyces stillatus. Nees, Syst., p. 89, f. 90; Cke., Hdbk., p. 352.

On pine and other decaying wood. Distinguished from *D. deliquescens* by its rather small size, firmer substance, deeper orange colour, and larger, multiseptate spores. Usually barren."

Massee describes these red fruit-bodies as being more or less plicate. My experience is that they are mostly hemispherical and irregularly humped or obtusely tuberculate rather than plicate. He also says: "spores cylindrical, curved, multiseptate, 18–22 × 7–8 μ," but he fails to tell his readers that by 'spores' he means not basidiospores, but *oidia* embedded in the gelatinous outer layer of the fruit-body. Each oidium has at least one septum across it, but the oidia hang together in chains and show all stages of separation from one another. Only the chains of oidia are multiseptate. The width of the oidia I find to be 2–4 μ and not 7–8 μ. They are but rarely as wide as the basidiospores. The 2-celled oidia are 12–15 μ long, but chains of these oidia imperfectly separated from one another may be 45 μ or even 60 μ long. The oidia are usually curved or undulate and are sometimes more or less Y-shaped. In each cell there are usually two small central rounded bright spots, so that the chains of cells are guttulate. The oidia on the exterior of the fruit-body produce a few tiny oval conidia about 2 μ long. If a red fruit-body be touched into a drop of water on a slide, some of these conidia can usually be found in the drop among the oidia, and occasionally one may find them attached to their oidia. Massee says that the fruit-bodies are "usually barren." Exactly what is meant by this is not clear. As a matter of fact the red fruit-bodies always produce a crop of oidia and never any basidiospores.

* G. Massee, *loc. cit.*, p. 67.

A brief description of *Dacryomyces deliquescens*, suited for systematic purposes, is as follows:

Dacryomyces deliquescens Duby.

Synonym for the oidial stage: *Dacryomyces stillatus* Nees.

Basidial fruit-body—gelatinous, convex, rounded, or irregular when confluent, often slightly plicate or gyrose, yellow, translucent, 1–6 mm. in diameter, basal portion emerging from the wood at the central point. Basidiospores cylindrical, curved, obtuse, 12–15 × 5–6 μ, 1-celled when discharged from the sterigmata but after lying in water soon becoming triseptate and 4-celled.

Oidial fruit-body—gelatinous, convex, mostly hemispherical, not plicate but when large often irregularly humped up at the surface, bright orange, rather opaque, 1–3 mm. in diameter, basal portion as before. Basidiospores never present. Oidia very numerous, embedded in the outer gelatinous layer which deliquesces in rainy weather and sets them free, formed in branching chains, cylindrical, curved or flexuose, sometimes forked, usually 2-celled but forming chains owing to imperfect separation, width 2–4 μ, length when 2-celled 12–15 μ, but forming chains up to 60 μ long, sometimes bearing one or two minute oval conidia 2 μ long, contents pale orange with one or two clear guttules in each cell.

Lignicolous, occurring on many different kinds of wood especially coniferous woods. Common everywhere, often seen in gardens on old pine boards, wooden rails, arbour-work, etc. It is to be found all the year round but is conspicuous only in wet weather.

The two forms of fruit-bodies were originally described by Duby and Nees as independent species and have always been so treated by systematists, the basidial form being called *Dacryomyces deliquescens* and the oidial form *D. stillatus*; but Brefeld has proved that they are nothing but two stages of the same species. They may be found separated from one another on different substrata, or in separate patches side by side on the same substratum, or occasionally intermingled. According to Tulasne some of the yellow fruit-bodies may at times be marked with red patches of the same nature as the red fruit-bodies.

SOME WOOD-STAINING FUNGI.

With Plates VIII and IX.

By B. D. MacCallum, M.A., D.Sc., F.L.S.

I. *Ceratostomella Piceae* Münch.

The first recorded observation of the cause of "blue-rot" in timber was made by Hartig(1), who noted that the "blueing" of pine-wood was due to the brown mycelium of a fungus which rapidly penetrated the whole trunk with the exception of the heart-wood. This fungus he described under the name of *Ceratostoma piliferum*. Saccardo(5) proposed the new genus *Ceratostomella* for all species with colourless ascospores.

In 1903 investigation of the "blueing" of pine timber began in America, and von Schrenk(6) submitted a report on it to the U.S. Department of Agriculture. He describes the perithecia of *Ceratostomella pilifera* Wint. as they occur on the wood of *Pinus ponderosa* and in artificial culture, and mentions the occurrence of conidial forms, but his investigations of these was unfinished. He was of opinion that the entrance of the fungi into the trunks of standing trees was through the galleries made by the bark beetle (*Dendroctonus ponderosae*), but it was to the attacks of the beetle and not of the fungus that he attributed the death of the trees. The paper also gives the result of tests of the strength and durability of the blue wood.

In 1906, Hedgcock(2) took up the work where von Schrenk had left it, and published the result of his investigation on "Chromogenic fungi which discolour wood," wherein he described numerous species of *Ceratostomella*, describing both conidial forms and perithecia, and, in addition, gave an account of other wood-staining fungi under the genera—*Graphium*, *Hormodendron*, *Hormiscium* and *Penicillium*.

In 1907, Ernst Münch(4) published "Die Blaufäule des Nadelholzes"—a paper embodying the result of most careful investigation of the genus *Ceratostomella*. Münch is of opinion that *Ceratostomella pilifera* Wint. must be regarded as a composite species and describes three of the constituent species—*C. Piceae*, *C. cana* and *C. coerulea*; a further species, *C. Pini*, is sharply marked off from the others by its much smaller, short-necked perithecium. The perithecia of the "pilifera group" are all of the same type, and these species differ only in their auxiliary fruit-forms.

In addition, Münch describes a new species, *Endoconidiophora coerulescens*, of which he says "As to another fungus (hitherto

included in *C. pilifera*) the perithecia of which are very like those of the three previously named (i.e. those of the 'pilifera group'), this must, on account of its characteristic auxiliary fructifications, form another genus."

The latest contribution to the literature of the subject is "Some Notes on Sap-stain Fungi," by E. E. Hubert(3). This is a description of the action of the fungi on the timber of various trees and the results of tests of the strength of the infected timber.

In this country "blue-rot" has been known for many years, and it has been assumed that it is caused by one or more species of *Ceratostomella*, but I have been unable to find any description of species occurring here. The present investigation has not been confined to *Ceratostomella*, for it was found that, in many cases, even where the characteristic blue stain was most pronounced, other fungi were present.

Pl. VIII is a photograph of a section of the trunk of a freshly-felled tree of *Pinus sylvestris*. At every point where the trunk and the branches were cut there was a well-defined blue band—the infected sap-wood—which was riddled with a network of brown hyphae (Pl. IX, fig. 1). From this wood several fungi were isolated, including two species of *Ceratostomella*. It is clear that the isolation of the components of such a mixed infection is a matter of considerable difficulty.

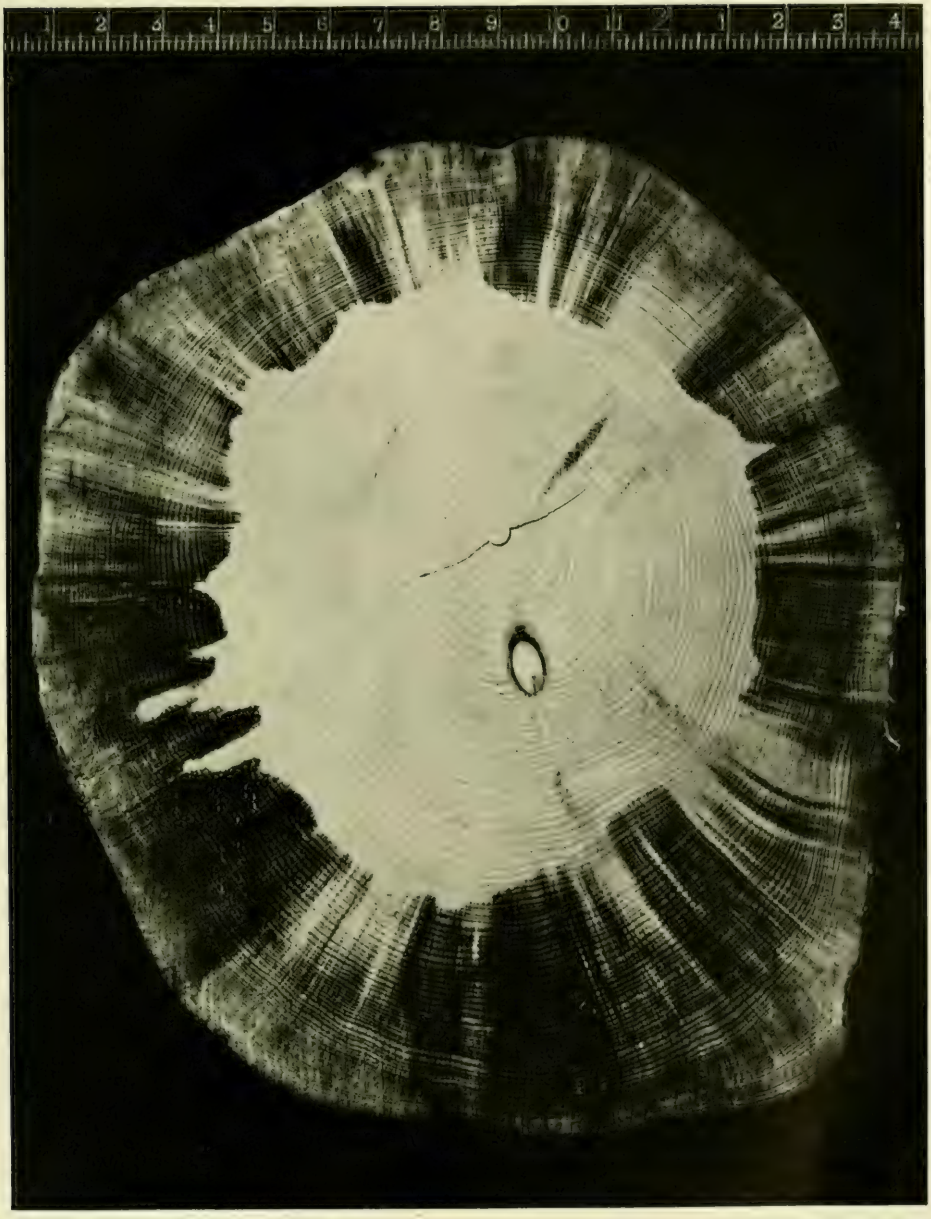
Of the genus *Ceratostomella*, I have found *C. Pini* Münch and *C. Piceae* Münch very commonly in and around Edinburgh and, indeed, in any woods visited between Edinburgh and Inverness, and have no doubt that they occur all over Scotland.

In Edinburgh it is so abundant that in any load of household wood (if it is of *Pinus sylvestris*) perithecia may be observed on almost every log, crowded in the cracks of the bark and on the surface of the wood. In some cases the sap-wood of standing trees was found badly attacked by these two species of *Ceratostomella* and other fungi, and it is interesting to note that in all cases which have come under my observation the bark of the tree was riddled with the holes made by the pine beetle (*Hylesinus piniperda*). This would appear to support von Schrenk's theory for the cause of death of the "blued" specimens of *Pinus ponderosa*.

Another point which may, perhaps, be of importance is that the dead trees were generally in marshy ground.

Ceratostomella Piceae Münch.

This fungus has been described by Münch as it occurs in Bavaria, but I am commencing my description of the wood-staining fungi with a short account of its life-history, as it


1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4

occurs so commonly in Great Britain, although it has not been recorded, and Münch's paper is not readily accessible. It is perhaps the easiest species to study, for although it is almost inextricably entangled with other fungi on *Pinus sylvestris* it produces a nearly "pure" growth on *Picea excelsa*. However, it may easily be overlooked, as the timber of the spruce is quite unstained. Münch is not quite certain how far *C. Piceae* stains wood, but states that fallen timber is sometimes blue, sometimes slightly darkened and sometimes quite unstained. So far as my observations go, in Scotland spruce timber is quite unstained even when perithecia occur thickly all over the surface, and, although *C. Piceae* occurs very frequently on badly stained *Pinus sylvestris*, I have never found it unaccompanied by other fungi. Moreover, pure cultures on sterilised pine blocks caused only a very slight discoloration. Certainly there was no trace of the characteristic blue colour always associated with attacks of *C. Pini*.

The principal media used for the cultivation of the fungus have been pine and spruce decoction agar (or gelatine) and plum agar. Very successful growths also were made on sterile blocks of moist sap-wood in deep Petri dishes or narrow strips in test tubes.

Fully developed perithecia were found throughout the autumn, and from the sticky mass on the top of the beak, streak cultures of ascospores were made. The ascospores germinate readily, and, after two days, a small mycelium of delicate, white, branching hyphae is formed. At the end of the second day conidia begin to appear, and on the third day the mycelium has produced numerous conidiophores, bearing conidia of the Cladosporium type (Pl. IX, fig. 2).

The conidiophores, which arise in the submerged part of the mycelium as well as aerially, are sometimes single and short, but more often they branch, the most characteristic form consisting of a fairly long stalk-like portion, from the end of which four to six branches radiate out, and these branches may branch again or conidia may be abstricted from their ends (Pl. IX, fig. 2). The whole conidiophore breaks up very readily and the conidia bud on the surface of the agar forming a yeast-like mass.

The size of the conidia varies enormously, the length being 4–15 μ, the width 2·5–3·5 μ.

In hanging drops of pine decoction the mycelium may produce conidiophores of this type, but more often there is a simple conidiophore, at the apex of which a whorl of conidia is formed (Pl. IX, fig. 2 *b*). These conidia vary very little in size, being 6–8 μ long and 2·5–3·5 μ wide.

In weak pine-decoction agar or gelatine, conidia of this second

type appear frequently, and another common form is that depicted in Pl. IX, fig. 2 *c*. In almost any culture also, conidia may arise from the mycelium without the formation of a conidiophore.

As the mycelium increases in size, strands of hyphae of a considerable thickness are often formed, and parts of these become at times almost black. They are often covered with a mass of conidia. From these coremia, as from the ordinary mycelium, conidia may arise without the production of a conidiophore. About the fourth day a new type of fructification arises—the Graphium form, which, as Münch notes, is probably the *Graphium penicillioides* Corda. The Graphia appear in great numbers along the streaks and are easily visible to the naked eye as stout cylindrical pillars surmounted by a spherical head (Pl. IX, fig. 4). Each one arises from a group of short swollen cells of the mycelium, numerous branches of which grow up together to form a thick strand, the lower part of which becomes quite black, while the upper part remains colourless. The hyphae forming this stalk are very narrow and not infrequently the outer cells are slightly twisted round the stalk (Pl. IX, fig. 4 *a*). The apex is at first pointed but later spreads out, the colourless hyphae branching and from these branches the very small (3–4 μ long, 1·5–1·75 μ wide) colourless conidia are cut off. When the Graphium is mature the head consists of a drop, milky below where the spores are collected but quite clear above. This drop, unlike that on the beak of the perithecium, mixes quite readily with water.

In older cultures, small Graphia often grow out from the main head, while the Cladosporium conidiophores may sprout from the stalk, producing a most complicated looking structure. At the end of two weeks, perithecia begin to appear, a perithecium often arising at the base of a Graphium. The time of appearance of the perithecia however, is rather variable, for sometimes without any apparent difference of conditions, they have been delayed until the sixth week, and, as Münch also found, their number is very variable, some cultures being studded thickly with perithecia, while others on the same media and under the same conditions, produce only a few. I have even had some without perithecia at all but with an enormous growth of mycelium. If, however, a piece of this mycelium was transferred to another agar plate perithecia were invariably produced.

The perithecium commences as a tangled mass of hyphae which are first a light, then a very dark brown, and finally decidedly black. For some time it grows as a dark spherical body invested with very fine, light-brown, hair-like hyphae. From its upper surface the beak then arises as a cylindrical

sheaf of narrow parallel hyphae slightly bent towards the end. The beak is black except at the tip where it is colourless (Pl. IX, fig. 7 *a*). At maturity the tip opens out to form a crown of bristles supporting the shiny yellowish mass of ascospores.

The diameter of the perithecium is 150–250 μ, the neck varies from ·85–1 mm. in length (though on *Pinus sylvestris* it is sometimes 1·2 mm. or more in length), 20–40 μ in width. The asci that I have found, agree with the description of Münch, not with that of von Schrenk or Hedgcock, but I have found them only occasionally and after much search, though Münch found them most abundantly. The ascus is almost spherical, 4·5–6 μ in diameter. It has an extremely delicate wall and in crush preparations it generally collapses. Münch finds 6–8 ascospores. I have found eight, apparently in two groups of four. The ascospores are 3–4·5 μ long, slightly curved, and rounded at both ends.

All attempts to isolate a single ascospore were barren, as no solvent of the slime could be found which did not destroy the ascospore, so that streak cultures only could be made and young single mycelia isolated from their ends and transferred to separate plates. This was done repeatedly and the same series resulted in all cases.

Cultures were also made from single spores of the Graphium, but with a disappointing result, for only the usual conidial forms and no perithecia were produced. Münch had exactly similar results and he acknowledges that this is very much against the theory that the Graphium is a stage in the life history of *C. Piceae*.

Just recently I have been making cultures from single conidia of the Cladosporium type, and in several cases have produced perithecia as well as Graphia. As I have had this result in only a few cultures, at the present moment I am willing to admit that this piece of evidence is not complete. Lack of time for research has prevented my repeating these rather tedious single spore cultivations, but I hope to do so at a later date.

It is clear that, if this result can be obtained in a sufficiently large number of cultures from a single conidium, there can be absolutely no objection to the inclusion of *Graphium penicillioides* as a stage in the life-history of *Ceratostomella Piceae*. Like Münch however, I am convinced that I have isolated numerous ascospores after germination and in each of these, have observed the same series of conidial and perithecial forms; namely, the Cladosporium type of conidiophore, followed by the Graphium fructification, these arising within a few days of germination, and finally, after two weeks or more, the perithecium.

The above description, of course, applies to cultures of

C. Piceae in artificial media. On the spruce a rather small mycelium is produced and it does not penetrate very far into the wood. It is white or slightly greenish in colour and produces on the surface the same conidial forms and perithecia as in artificial culture. The Graphia are extremely numerous, but the perithecia vary in number, sometimes studding the wood closely, sometimes appearing singly here and there among the Graphia.

Summary.

In my investigation of *Ceratostomella Piceae* Münch, my results are similar to those of Münch, that is that *Graphium penicillioides* Corda must be considered a stage in the life-history of *Ceratostomella Piceae.*

BIBLIOGRAPHY.

(1) Hartig, R.—Lehrbuch der Pflanzenkrankheiten, pp. 75 and 106, 1900.
(2) Hedgcock, G. G.—Studies upon some Chromogenic Fungi which discolour wood. Missouri Botanical Garden. Seventeenth Annual Report, St Louis, 1906.
(3) Hubert, E. E.—Notes on Sap-stain Fungi. Phytopathology, 11 (1921).
(4) Münch, E.—Die Blaufäule des Nadelholzes in Naturwissenschaftlichen Zeitschrift für Forst und Landwirtschaft, 1907–1908.
(5) Saccardo, P. A.—Michelia, 1. p. 370, 1878. Sylloge Fungorum, I–XVII.
(6) Von Schrenk, H.—The "blueing" and the red rot of the Yellow Western Pine. U.S. Dept. of Agriculture, Bureau of Plant Industry Bulletin, No. 36, Washington, 1903.

DESCRIPTION OF PLATES.

Plate VIII. Photograph of transverse section of the trunk of a freshly felled tree of *Pinus sylvestris* showing sap-wood stained deep blue—in places nearly black—by a mixed infection of fungi.

Plate IX. Fig. 1. Section of sap-wood of Plate VIII showing brown hyphae of fungi running along tracheides and filling medullary rays. ×800. Wide hyphae are often found where cells of medullary ray are destroyed.

Figs. 2–7. Ceratostomella Piceae.

Fig. 2. (*a*) Mycelium from germinating ascospore showing conidiophore of usual Cladosporium type. ×400. (*b*), (*c*), (*d*) Conidia from hanging drops of weak pine and spruce decoction.

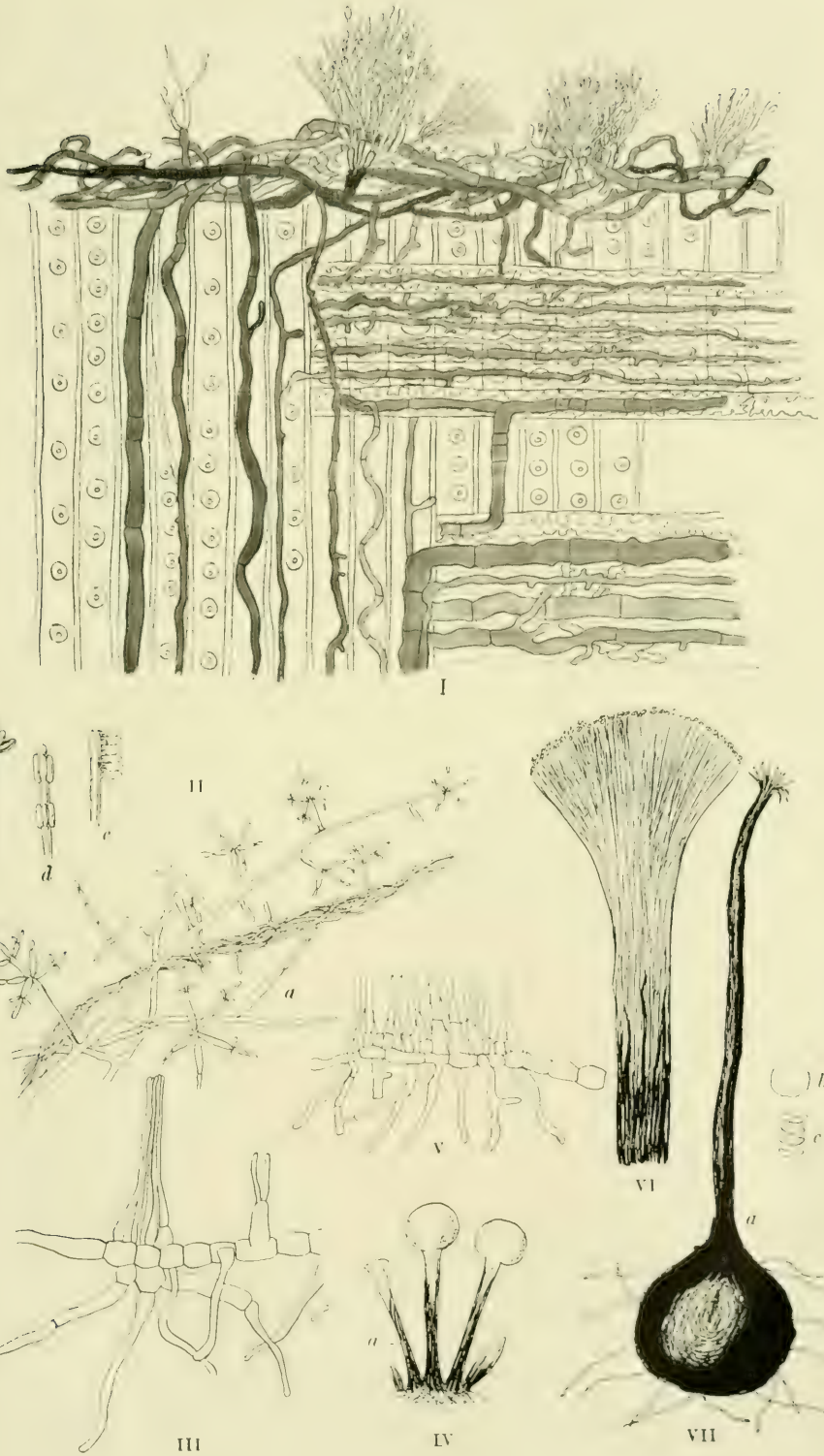
Fig. 3. Row of beaded mycelial cells from which young Graphia arise, the mooring hyphae are conspicuously brown in the more or less colourless mycelium.

Fig. 4. A group of Graphia. ×25.

Fig. 5. Base of a young Graphium.

Fig. 6. Tip of Graphium before production of the drop. ×150.

Fig. 7 (*a*) The perithecium. ×65.
(*b*) Wall of ascus. ×650.
(*c*) Ascospores. ×500.


I
II
b
c
d
a
V
VI
b
c
a
III
a
IV
VII

THE NATIONAL COLLECTION OF TYPE CULTURES.

By R. St John Brooks, M.D., D.P.H., M.A.

The inception of the National Collection of Type Cultures was due to the initiative of the Medical Research Committee (now the Medical Research Council), who had long had in view the formation of a collection where biologists in general and bacteriologists in particular might obtain authentic strains of bacteria, protozoa, etc., for use in scientific work. The need of an available supply of this kind had long been felt in many directions and particularly in medical research work, for the study of principles and methods in bacteriological technique and for the systematic classification of bacteria, protozoa, etc., in their various species and strains.

In the past the needs of workers in this respect had never been fully met. In this country the Lister Institute of Preventive Medicine had for many years assisted bacteriologists both at home and abroad, so far as the resources of its own private collection permitted, but British workers had been dependent in great part upon the courtesy of scientific colleagues or upon the collections of Institutes in other countries. Before the war the collection of the Pasteur Institute in Paris, maintained by M. Binot, was very helpful to workers here. A collection of type cultures was formerly maintained on a commerical basis by Král at Prague and this was subsequently transferred to the Sero-physiological Institute of Vienna. In America, the Museum of Natural History in New York has maintained a Culture Bureau during the last nine years and it is believed that the activities of the Bureau have been of the greatest benefit to workers there.

Early last year the Medical Research Council were able, by the courtesy of the Governing Body of the Lister Institute, to make arrangements to maintain a National Collection of Type Cultures at the Institute, where all the necessary facilities had been provided. The scheme is under the general direction, on behalf of the Council, of Prof. J. C. G. Ledingham, a member of the Staff of the Lister Institute, the writer being appointed by the Council to be Curator of the Collection with Miss M. Rhodes as Assistant Curator.

Since the formation of the Collection in January 1921 some twelve hundred strains of micro-organisms of medical, veterinary and economic importance have been incorporated in the collection and cultures have been distributed to workers at home and

abroad at the rate of about two thousand per annum. This number is expected to show considerable increase in the not distant future. A catalogue giving all the strains conserved up to date is at present in the press and is expected to be available for distribution very shortly. The Staff are prepared to give assistance in the identification and classification of strains sent in by correspondents.

Mycological Collection.

During the early part of the current year it was proposed to extend the scope of the National Collection by including representative fungi derived from various sources. As was the case with bacteria, so also the need of a Mycological Collection had long been felt. To some extent the Centraalbureau voor Schimmelcultures, Amsterdam (now at Baarn), had been found useful by British and Imperial botanists, but it was the general opinion that a collection of fungi in this country was very necessary for the co-ordination of research. No other Institution contemplated the formation of such a collection at that time and the National Collection was glad to be in a position to offer its services to Mycologists. In order to insure that this side of the collection might be made of the most value, the British Mycological Society were asked to appoint a fully representative standing committee to advise and assist in all questions appertaining to fungi. The following members of the Society were appointed:

Prof. V. H. Blackman	Dr E. J. Butler (*Chairman*)
Mr W. B. Brierley	Mr A. D. Cotton
Mr F. T. Brooks	Mr J. Ramsbottom
Dr R. St John Brooks	Miss E. M. Wakefield.

The scope of the Mycological Collection includes the collection and maintenance of cultures of fungi of importance in phytopathology, medicine, veterinary science, technology and soil biology, types useful for teaching purposes and any rare or interesting species. At present it is not possible to cope with the innumerable strains of common fungi and only room can be found for those forms with some published distinguishing name or symbol.

It is found necessary at present to restrict the collection to fully identified species of fungi and in sending these it should be stated by whom they were named, and also whether a special medium is required for their growth, as only a few standard media are in general use in the collection. It must naturally be left to the discretion of the Curator and the Advisory Committee to decide whether given cultures are of

sufficient importance to be maintained in the collection. Cultures will be supplied on demand, so far as possible, to workers at home and abroad and, as a rule, a small charge will be made to defray the cost of media and postage.

Annual lists of the fungi in the collection will be published in the Transactions of the British Mycological Society. A set of type slides of fungi will be kept in the Botanical Department of the British Museum (Natural History) in addition to a working set at the Lister Institute.

NOTES ON MALAYAN MYCETOZOA.

By A. R. Sanderson, F.L.S.

The part of the Malayan Peninsula dealt with in the present paper lies between North Latitude 1° and 6° and East Longitude 100° and 104°. It is a long narrow spit of land pointing south. An irregular ridge of mountains extends from north to south of the peninsula, some of the peaks rise to over 6000 ft., but all are clothed to the summit with tropical forest.

The climate throughout the year is warm, moist and equable; the rainfall is abundant and not confined to any one season (see notes on rainfall below), the tropical vegetation is luxuriant.

Apart from gatherings by Haviland, Burkill, Chipp and Sappan, very few records for Mycetozoa in Malaya existed prior to 1918. Although a considerable number have been added since, the present paper cannot claim to be more than a preliminary report, the observations as noted being records made at odd moments and at more or less irregular intervals; they merely indicate what a fruitful field awaits the enthusiast who has ample time at his disposal to investigate the distribution in the tropics not only of Mycetozoa but of fungi and cryptogams in general.

Before proceeding to deal with the various species of Malayan Mycetozoa and their habitats, it is advisable to consider the peculiar conditions prevailing in Malaya, more particularly along the western half, that is over all of the peninsula bounded on the east by the natural barrier of mountains.

Large tracts of tropical virgin forest have been cut down, one might almost say ruthlessly destroyed, in order to clear land chiefly for the purpose of planting rubber trees, *Hevea brasiliensis*. It is likely that further portions of forest will share the same fate in the near future, especially in the states of Pahang and Kelantan which lie in the eastern half of the peninsula. Probably over one and a half million acres of the land which

has been cleared of jungle is already planted with this one species *Hevea brasiliensis*. The rubber plantations must therefore be regarded for the present purpose as forming a more or less continuous forest. The ground beneath the trees is kept fairly clean weeded, a very different state of things from the natural forest with its inextricable tangle of low growing plants and creepers. While the trunks of the native trees usually carry a rich and varied epiphytic vegetation, those of the rubber trees are comparatively clean. There are also extensive coconut plantations, and here we have another case of large areas given up to a single species of tree. Belts of forest reserve to some extent interrupt the continuity of the plantations but they are for the most part narrow, and in the western portion of the peninsula rarely exceed a few miles in depth.

When searching for Mycetozoa, rubber and coconut trees received special attention, partly because they were more easily examined, and also because they were most productive. I think it may be safely assumed that the Mycetozoa occurring on these trees have spread there from the jungle from the fact that a large proportion of the species which have been found on Hevea and coconut are also recorded on jungle timber. Hevea is a soft timber and yields a never-ending supply of decaying wood in the form of logs, stumps and boughs which are the result of thinning out or cutting down because of disease; they form a very favourable nursery for Mycetozoa. Thinned out timber, and diseased logs and stumps of Hevea are usually destroyed by burning in prepared pits (fire-pits) or are taken away and stacked for use as fuel; the half-burnt and stacked material has many times proved most productive of Mycetozoa.

The virgin forest consists of an intimate mixture of hard, medium and soft wooded trees, the medium and soft woods probably predominating except in certain districts. Conifers are practically limited to a single species, the Dammar (*Agathis alba* Lam.), which occurs only sparingly. There is therefore no area of jungle which as regards conifers is comparable to a pine forest in temperate regions. The nearest approach to a natural forest consisting of only few species is to be found perhaps in the mangrove swamps.

The hard timber usually decays extremely slowly and from it both fungi and Mycetozoa are usually absent or occur only sparingly. This apparent scarcity is probably due to the fact that the succession of saprophytes is spread over a much longer period owing to the slower rate of decay. On two hard-wood trees, however—Merbau (*Intsia Bakeri* Prain) and Rassa (*Shorea barbata* Brandis)—I have gathered small colonies of *Physarum nucleatum* and *P. auriscalpium* not longer than three weeks after

felling. The method of felling is to cut into one side 3 to 4 ft. from the ground with an axe, the tree falling over towards the cut side. On the top of the stump a brush of torn wood fibres is usually left; on these the sporangia of Mycetozoa are found, and also in the deep cracks in the wood which are constantly damp since the stumps are in dense forest. The soft woods which decay rapidly provide the most suitable habitats for fungi and Mycetozoa generally.

So far as my experience goes, dead leaves, fallen twigs and dead herbaceous plants have been singularly unproductive of Mycetozoa, but a few striking instances have been noted of their occurring amongst rank decaying vegetation even in the gloomy depths of heavy jungle. In some cases they have been observed on fallen leaves before decay has advanced very far; it was then difficult to determine whether the plasmodia actually developed on the leaf, or crept to that position from other material and continued to feed there, or merely passed on to the leaves to fruit. As even living leaves in the tropical forests often carry a micro-flora consisting of algae, mosses, hepatics and lichens, it is quite possible there may be sufficient material on nearly fresh leaves to feed plasmodia. When once leaf-decay sets in a host of fungi and bacteria quickly appear and complete the process of destruction.

Although the decaying leaves and vegetable débris on the ground have not so far proved productive, yet similar material collected in the fork of a branch or about dead leaf-bases still attached to the tree may often yield quite a large number of species.

The trunks of living trees covered with a rich epiphytic flora of ferns, mosses and lichens, provide Mycetozoa with a suitable arboreal habitat. The arboreal species almost invariably occur along the lines of the natural rain track down the trunk, the direction of the lines being determined by the branching of the trunks or in the case of the palms by the arrangement of the leaf-bases. According to my observations the leaf-bases of wild bananas and some aroids have never provided a single species.

From the very equable temperature and from the rainfall being distributed throughout the year, it is not surprising that many species of Mycetozoa seem to have no definite season for making their appearance, and sclerotium, the resting stage of plasmodium, is rarely met with, at least in the district of Petaling.

So far as my limited experience goes, Mycetozoa require very careful search in the virgin forest, the results being as a rule disappointing. This apparent scarcity, for I believe it is only apparent, may be due largely to the wealth of insect life, which

although not always evident from a superficial survey, is at once revealed when one looks more closely. Ants of many species abound almost everywhere, and they devour the sporangia of some Mycetozoa eagerly. The larvae of various coleoptera, lepidoptera and diptera also do their share; as a rule their attentions are directed to the immature or freshly matured sporangia; for some reason the stalks are frequently left. Besides these foes they are subject to attack by various small beetles, but probably ants do most damage. I have frequently observed ants devouring immature sporangia of *Arcyria denudata* and *Hemitrichia clavata*, while a small tiger beetle has apparently acquired a taste for *Perichaena vermicularis*. Fungi and bacteria seem to be equally effective in causing the rapid destruction of mature sporangia and heavy rain washes them away. Hence it follows that unless one is fortunate enough to see a colony almost immediately after it has matured the whole may quickly disappear.

Almost the first point that one notes with regard to tropical Mycetozoa is the absence or rarity of certain species which are exceedingly common in temperate climates, such for example as *Physarum nutans* and *Trichia varia*. The question of temperature is suggested as a possible reason for this as I believe that in temperate regions the majority of species reach maturity during the cooler periods of the autumn months and early spring. The abundance of other species in the tropics which are rare elsewhere, is equally noteworthy.

Collecting and preserving specimens.

A few notes on preserving the specimens of Mycetozoa in the tropics may not be out of place.

In the field I find lightly wrapping each gathering in a separate piece of paper on which is written any note which may be useful afterwards is all that is necessary. On returning to the house these are placed at once in a desiccator over benzine fumes and left for half to one hour. I found this a very necessary precaution to kill the numerous small insects, larvae, etc., which otherwise might, and on occasion did, consume the sporangia. Each specimen is then transferred to a match box or larger box as required, and is labelled with date, locality and the material on which the sporangia formed.

The next thing is to get the gathering dried as quickly as possible, and this I usually did by exposing it to the sun on a small, low bench, the legs of which stood in cups containing crude creosote. If the specimen is on wood this had been soaked previously with the same material; this ensures against insect attack while drying.

Once thoroughly dried the collection is put away in large tin boxes (usually biscuit boxes) with a liberal supply of naphthalene balls. Even with these precautions I have lost some specimens, eaten by insects. The climate is so damp that I find it necessary to expose to the sun at intervals, always taking precautions to keep off small insects. In some cases I have had to expose sporangia to benzine fumes a second and third time. At first I tried chloroform instead of benzine, but I believe this caused some of the specimens to fade a little.

List of Mycetozoa found in South Malaya.

Ceratiomyxa fruticulosa Macbr. The species occurs commonly both in the lowlands and up to 2700 ft., sometimes in very large colonies. Most frequently it appears on logs which have reached an advanced state of decay, but once I saw a fine colony on a Ficus stump in which decay had not progressed far.

C. fruticulosa var. *flexuosa* Lister. The variety is almost as frequent as the species. Both are widely distributed.

Badhamia orbiculata Rex. This species occurs very frequently on living Hevea trees, sometimes in large colonies; it is almost as common on the trunks of coconut palms, and in both cases is always to be found along a water trickle. I have searched in vain for it on other trees in the jungle and have rarely seen it on fallen logs of Hevea or on decayed coconut stems on the ground. On several occasions it has occurred in large masses on living coconut palms up to a height of over 15 ft. In dry weather when dehiscence of sporangia takes place the white rod-like projections of the capillitium from the sporangium wall inwards are an unmistakable feature. About the middle of December 1920, while visiting Kuala Lumpur, I noticed that six coconut palms appeared as though sprinkled with white-wash on one side from about 20 ft. to the base of the trees; closer examination showed this to be entirely due to *B. orbiculata* —a most striking appearance.

Badhamia affinis Rost. This is apparently a rare species in Malaya.

Physarum melleum Mass. Very extensive colonies of this species occur fairly frequently, sometimes on decaying leaves and twigs, at other times on dead timber, especially of Hevea; on two occasions I found it covering the fructifications of *Ustulina zonata*, and once on *Fomes lignosus*. It appears to be one of the seasonal forms, since for several months at a time no trace of it appears. The colour of the plasmodium is somewhat variable, sometimes being, as Petch described it, a watery yellow, and at other times a very bright opaque yellow. Later observations of the plasmodium showed that it increased in

depth of colour and in opacity just before the formation of sporangia. One doubtful gathering turned out to be this species with lime-knots yellower than typical.

Physarum columbinum (Berk. and Curt.) Sturgis (syn. *P. compactum* Lister). This I have gathered twice, once near the base of an old jungle stump in Johore, a part of the colony being on the soil. The stump was one of many left after felling in the course of clearing. Most of the sporangia had either been eaten or knocked off. On the second occasion I found an extremely large colony consisting of many thousands of sporangia; they are dull grey in colour and deeply umbilicate above, so that I at first regarded them as *Physarum javanicum* Racib. The stalks are often very short and are dull yellow in colour; the enclosed lime is not in granules as usual, but is compacted into large crystalline nodules. The plasmodium, a large anastomosing network of somewhat thick, dirty grey opaque veins, resembled that of *Physarum nutans* Pers. This was spread over the base of an old Ficus stump and on the damp earth near the edge of the jungle.

P. viride Pers. *P. viride* var. *incanum* Lister.
P. viride var. *aurantium* Lister. *P. viride* var. *rigidum* Lister.

This species with its varieties appears to be the commonest representative of the genus in tropical Malaya. The type is I think less common than the varieties; var. *aurantium* is very frequent on the leaf-bases of coconut palms, generally on the inner surfaces; var. *incanum* occurs in similar situations to the preceding, and much more rarely on fallen leaf-bases of some other palms; var. *rigidum* is by far the commonest form, immense colonies appearing with great regularity, and very frequently on *Schizophyllum commune* which is a frequent saprophyte on Hevea and other timbers. Twice I have seen small developments of this variety on species of polypores (see p. 299).

P. auriscalpium Cooke. This species occurs, but not commonly, on the leaf-bases of palms, usually while the leaf-stalks still remain attached to the trunk. Several times I found small colonies on bunches of dead leaves of *Passiflora* sp. and *Gardenia* sp. which were either suspended from or caught in the fork of a tree. Once a colony appeared on a stripped surface trunk of Hevea. The cortex had been removed from a portion of the stem as an experiment, leaving only the cambium and a few layers of cells covering the woody tissue. The regenerated cortex was killed by an inoculation with a fungus and the resulting diseased tissue yielded a fine colony of *Physarum auriscalpium* three weeks after stripping. I failed to notice the plasmodium. On several occasions large colonies of this species

have appeared on the tapped surfaces of Hevea attacked by *Sphaeronema fimbriatum* ("Mouldy Rot of the Tapped Surface").

P. nucleatum Rex. This also is moderately frequent on palms in similar situations to *P. auriscalpium*; I have also found both species on torn wood-fibres of *Intsia Bakeri* and *Shorea barbata* about three weeks after the trees were felled. Unless one is fortunate enough to see it before or soon after the sporangia begin to dehisce most of the minute central balls of calcareous matter will have fallen out.

P. reniforme Lister. This occurs on Hevea logs, and on a few occasions I have met with it 5 to 7 ft. high on the living stems. It has appeared twice on Hevea just below a diseased portion of the cortex where fluid was exuding from holes made by boring beetles (a species of Xyleborus); the colony of sporangia followed the line of the stream of fluid; once it appeared on the dead cortex of Hevea attacked by *Ustulina zonata*.

Two forms of the species occur; one with long-stalked hammer-headed sporangia, like the type from Ceylon, with rough spores, 12–14 μ diameter; the other with smaller and less rough spores measuring 10–12 μ, and with the sporangia in close clusters; the latter form is fairly frequent.

P. pusillum Lister. One gathering only.

P. virescens Ditm. One small colony from jungle, in Johore.

P. lateritium Morgan. This species occurred continuously on soft-wood jungle logs during July, August and September 1920. The plasmodium was a dirty chocolate grey and persisted for some considerable time as very thick anastomosing veins. The young sporangia were brilliant yellow, rapidly darkening to a yellow-brown with age.

Fuligo septica Gmelin. Although I have several times gathered this species both in Malaya and Ceylon it is apparently not very common there. On five occasions I have found it on jungle-logs and several times on Hevea logs, but the aethalia were always somewhat small, never exceeding 5 cm. across. The lime contents seemed greater than is usual with the English specimens I have examined. One large specimen 10 cm. diameter was found on a Nibung palm (*Oncosperma filamentosa*) stump near Petaling. Very frequently the aethalia are reduced to a mere shell, the spores having been consumed by small beetles.

F. cinerea Morgan. This species occurred frequently on stacked Hevea and jungle timber at Petaling during the early part of 1921. As with the preceding, small beetles frequently attack the spores.

Erionema aureum Penz. Several times I have been fortunate enough to find this species. Once it occurred on a jungle log in an advanced stage of decay which had been exposed during

planting operations. Three gatherings were made in Johore, two being on much decayed logs and stumps of Kumpas (*Koompassia malaccensis* Maingay). One of these logs was almost covered with an immense colony of *Cribraria intricata*. The third gathering of Erionema, a very large one, was on the upper surface of a large polypore. When I found this I had no box to place it in, so I carefully moved it, anticipating picking it up later; when two days later I returned, there had been several violent rain storms and little trace of the Erionema was left on the fungus. A rich chrome yellow plasmodium which was issuing from the cut end of a very old hard-wood stump developed ten days later into small colonies of this species. The bright colour does not agree with the "colourless or pale yellow" plasmodium described in Lister's monograph.

Trichamphora pezizoides Jungh. This is one of the common species found on Hevea logs both in Ceylon and in Malaya. It occurs also on other wood, especially on felled timber which has been stacked for some time. Colonies of large size are frequent. Early in December 1920 I found this species on an old Hevea log which I had kept under observation for some months, and from which I had collected the mature sporangia a fortnight before. The log, which was lying on the edge of the jungle, was almost covered with a remarkable development of the dirty grey plasmodium. In many places the fine network of veins had given place to a complete sheet, and the main veins were in places half-an-inch in diameter. Altogether, the plasmodium, which had spread over various adjacent species of the higher fungi, including *Daldinea* sp., *Tremellina* sp., *Ustulina zonata* and *Schizophyllum commune*, must have covered many square feet. When crawling on the fungi the plasmodium was apparently much more watery and lighter in colour*.

Physarella oblonga Morgan. So far as my experience goes this is one of, if not the commonest species in tropical Malaya, more especially in the lowlands below 500 ft. One can be almost certain of a gathering at any time of the year by examining a few decaying logs of *Hevea brasiliensis*. Very large colonies of typical sporangia are frequent, and occasionally confluent forms occur. The plasmodium resembles that of *Badhamia utricularis* in colour and usually leaves very definite tracings of brown residual matter. When the sporangia dehisce the beautiful rich yellow columella is a marked feature and readily distinguishes it. For some reason the various insects which quickly destroy many species leave this one severely alone.

* The appearance of the plasmodium of *Physarum viride* var. *rigidum* changes in a similar manner when developing on some species of fungi, and the plasmodium of *Badhamia utricularis* reacts similarly when cultivated on the common mushroom.

Cienkowskia reticulata Rost. I had three gatherings of this species. One was a very fine colony spread over the bases of palm leaves lying on the ground and over some leaflets of Hevea. The portions which were dehiscing showed the deep orange base of the sporangium lying close to the substratum, as well as the delicate pale yellow capillitium and dark spores. This species is unmistakable after being once seen in the field. A second specimen, consisting of two small colonies, was found also on palm; a third small growth was on a somewhat decayed jungle log.

Craterium minutum Fries. Only once have I gathered a very meagre colony of this species which is so common in England. It was on some leaves and débris on the edge of a jungle swamp where many leaves and twigs showed tracks of plasmodium.

Diderma arboreum G. Lister and Petch. This species occurs on the living trunks of coconut palms and Hevea but apparently is not very common. I have found fairly large colonies on a decayed log in the jungle, and once I noticed it on a living Hevea tree, immediately after felling, at a height of about 30 ft.

D. effusum Morg. This species has been observed on dead leaves, but is apparently not common.

D. hemisphericum Hornem. This occurs in similar situations to the preceding; I have once seen it on bases of coconut leaves.

Diachea leucopoda Rost. I have twice found very extensive growths of this species, once on decaying Hevea leaves and twigs, and once on dead leaves of Gardenias and Crotons.

Didymium Clavus Rost. This is very common in small widely scattered colonies on decaying leaves of many kinds.

D. nigripes Fr. One gathering only.

Stemonitis fusca Roth. This species is very frequent on rotting jungle logs, especially those in drier situations, and on the under surface of Hevea tap roots which have been dug out because of disease. It also occurs very commonly in fire-pits on half-burnt Hevea and on many other logs left on the ground after a "burn off," i.e. clearing the land of jungle.

S. splendens Rost. Although not nearly so frequent as *S. fusca* this is fairly common, especially on Hevea logs, and is one of the earliest to appear; the sporangia are frequently very long and densely fasciculate.

S. ferruginea Ehrenb. This is almost as common as *S. fusca* and occurs in similar situations. Usually the development takes place in a series of somewhat scattered small groups.

Comatricha laxa Rost. This is represented by two small gatherings.

C. pulchella Rost. This species has occurred twice, once on leaves of Gardenia and Thunbergia in Selangar, and the second

time in great profusion on various dead leaves but especially on Rassa (*Shorea barbata*) in Johore. Several square feet of material were more or less covered with the sporangia which in places were densely aggregated. In the first gathering the sporangia vary in the denseness of the capillitium, some having an extremely lax capillitium, while others have a denser intermediate system of threads and something of an imperfect surface net on the lower half.

C. typhoides Rost. This seems to be by no means a common species, and the colonies I have seen have usually been small. One exceptionally large growth occurred however on a very much decayed log of "Jak" (*Artocarpus integrifolia*) in an abandoned garden.

C. longa Peck. Of the species of Comatricha this is one of the commonest, especially on Hevea logs which are in an advanced stage of decay. The long black sporangia densely aggregated and drooping are very characteristic. It frequently appears also on the soil around rotting stumps and on several occasions I have seen it on half-burnt Hevea logs in fire-pits. On cutting away a freshly matured colony the wood beneath frequently shows rich bright almost gamboge yellow coloration due to the plasmodium; this occasionally extends to a depth of one-eighth of an inch.

C. irregularis Rex? One doubtful gathering of this species was made varying somewhat from the typical form. Miss Lister describes the capillitium as stouter and darker at the extremities than any specimen previously seen, the columella being more rigid and the spores bigger and more spinose. The specimen is in a damaged condition.

Lamproderma arcyrionema Rost. This is the only representative of the genus recorded from Malaya. It occurred only on three occasions, each time in large colonies. Once it had developed on leaf-bases (outsides) of coconuts.

Cribraria violacea Rex. I have found this on coconut palms many times; it was plentiful on the insides of decaying leaf bases where there is much decaying vegetable matter and abundant moisture. It may be quite common in such situations but it is difficult to see. Once it occurred on "Nibung" palm (*Oncosperma filamentosa*).

C. intricata Schrad. This species occurs on coconut palms fairly frequently and on two occasions in Johore I have seen very large colonies each numbering thousands of sporangia crowded together on old Kumpas logs (*Koompassia malaccensis*). The dark lead coloured plasmodium was observed in the decayed timber.

Dictydium cancellatum Macbr. This very common species

occurs in immense colonies, but is seldom in perfect condition, as various insects and their larvae eat the sporangia.

Tubifera ferruginosa Gmel. One gathering only.

T. stipitata Macbr. My first gathering of this was from an old Ficus stump, the next from the bath room floor; several times I have found it on Hevea logs. It is apparently much more common in Malaya than the preceding species, frequently occurring in great abundance; on one stump I collected 50 aethalia: twice I have found it on Kumpas logs.

Alwisia Bombarda Berk. & Br. I have found this on three occasions on decayed jungle timber where a clearing had recently been made. One colony was small and not in good condition; the second, a very large one, was collected in Johore on "merbau" (*Intsia Bakeri* Prain). Another development was seen covering the end of a moss-covered rotten jungle log, and this seems its favourite habitat. It has not been my good fortune to see the plasmodium of this species. Usually the sporangia bear evidence of being partly eaten by insects. In suitable habitats it is probably not uncommon.

Dictydiaethalium plumbeum Rost. This species has been gathered on Hevea logs, jungle logs, and on dead leaves. One aethalium was over 4 cm. diameter.

Reticularia Lycoperdon Bull. This is not uncommon on Hevea logs, but the aethalia are small, rarely exceeding 3 to 4 cm. in diameter and it is difficult to find a perfect specimen. As in some English specimens, dipterous larvae feed on the immature aethalia.

Lycogala epidendrum Fries. Scanty colonies of small aethalia are fairly frequent on Hevea logs, where on one occasion I found a typical colony of scores of aethalia crowded together. I have also seen it on Nibung palm.

The genus Trichia in my experience is not commonly represented in Malaya. Such species as *Trichia varia* Pers., *T. decipiens* Pers. and *T. Botrytis* Pers., all of which are exceedingly abundant in Britain and throughout the temperate regions, I have not yet seen in these parts, even when searching at 2700 ft. altitude. I have only gathered two species of the genus, and these by no means frequently.

T. affinis de Bary. This occurs sparingly on decayed jungle logs and to a limited extent on Hevea and on dead leaves.

T. persimilis Karst. Like the preceding this is far from common; it occurs in similar situations.

Hemitrichia Vesparium Macbr. I met with this species once only in Malaya, on old rubber wood. The gathering was typical but small and showed signs of insect attack.

H. clavata Rost. This occurs much more frequently than the

preceding, the commonest habitat being the leaf-bases of coconut palms. I have also seen it often as an arboreal species on living Hevea and on several palms in the jungle, but the best developments are on Hevea logs. It is very liable to be eaten by insects.

H. Serpula Rost. This also occurs on the leaf-bases of coconut palms both on the inner surface and on the persistent fibrous decayed sheaths. In such situations it is very common and can be found all the year round. Less frequently it appears on Hevea, and on one occasion I saw a small isolated specimen on a decayed jungle log.

Arcyria ferruginea Sauter. The usual habitat of this species is the remains of Hevea logs and stumps in fire-pits, and on heaps of diseased lateral roots of Hevea; in both situations large colonies are fairly frequent. Occasionally it appears on fallen decaying branches of Hevea.

A. cinerea Pers. This is much more common than the preceding species. Large growths have appeared on the under surfaces of diseased Hevea tap roots which have been pulled up. It occurs sparingly on trunks of living coconut palms and on living Hevea trunks, the sporangia in such situations usually being very much scattered. A scattered form also occurs on living jungle trees. The "digitate" or clustered form is especially characteristic of developments of palm stems.

A. denudata Wettst. This species is very common on fuel heaps of split timber and on small diseased roots of Hevea, especially those affected with *Sphaerostilbe repens*. I once gathered it on dead leaves of Gardenia, associated with *Comatricha pulchella*. It is very frequent on half-burnt logs and stumps in fire-pits.

A. nutans Grev. Though not so abundant as the preceding species it is fairly frequent, and varies somewhat in colour from a decided buff to a browner tint somewhat resembling *Arcyria ferruginea* in older specimens.

A. virescens G. Lister. This striking species was recently described by Miss G. Lister (see Journal of Botany, LIX. 252, Sept. 1921). The green spores at first led me to believe this was a form of *A. glauca*, but it differs from that species in the long dark stalks and stouter capillitium marked with groups of prominent bars. Much-faded specimens, from which most of the spores had disappeared, have several times been passed as over-faded *Arcyria nutans*. The species is not uncommon in Johore where it occurs on jungle logs, sometimes in colonies of considerable size. It has several times been found in Selangor on stacked fuel timber of various kinds.

A. insignis Kalchbr. and Cooke. I once found this species

on the unusual habitat of dead leaves. The small scattered sporangia varied from 0·15 to 0·7 mm. in total height. Miss Lister who examined the specimen remarked of this, "It seems to correspond in character with the leaf-haunting form of *A. cinerea*, i.e. it bears the same relation to the usual wood form that the leaf form of *A. cinerea* does to the typical form on wood."

Perichaena vermicularis Rost. This occurs frequently, especially as an arboreal form on Hevea and palms. I once gathered some fine sporangia from a newly felled Hevea tree; they occurred quite 40 ft. up the stem and were associated with scattered groups of *Badhamia orbiculata*. Diseased Hevea trees are usually attacked by species of boring beetles. From the punctures 2 to 6 ft. from the ground a liquid in the form of bubbles of fermenting sap exudes and flows in a thin stream down the trunk; the track of these streams appears to be particularly favourable for the development of this Perichaena. One specimen was gathered from a jungle log at an altitude of over 2000 ft. in Negri Sembilan.

P. depressa Libert. This is fairly frequent, the sporangia occurring in the cracks of bark.

P. chrysosperma Lister. Three gatherings of this species have been made, two being on *Hevea brasiliensis*, and one on Nibung palm.

Margarita metallica Lister. I have found this sparingly among the moss and algae on tree trunks in situations similar to those frequented by *Badhamia orbiculata*. Coconut palms appear to be the trees most favoured. A somewhat abnormal specimen was found on a dark felt of algae on coconut wood; it consisted of long slender lilac-pink plasmodiocarps with rather stout capillitium threads.

Distribution of rainfall in Malaya.

The rainfall records as under for three successive years may be taken as fairly typical. The records "A," "B," and "C" are for districts near to the mountains or approaching the foot-hills.

A. Northern Johore:

1918	121·3	inches (total for year)
1919	97·5	,,
1920	103·7	,,

B. Central Negri Sembilan, near Seremban:

1918	85·1	inches
1919	93·8	,,
1920	101·3	,,

C. Northern Selangor, near Kuala Kubu:

1918	108·5	inches
1919	85·7	,,
1920	92·0	,,

The rainfall chart appended is for the Jeram district of Selangor. This is fairly typical for the drier low-lying plains near the western coast.

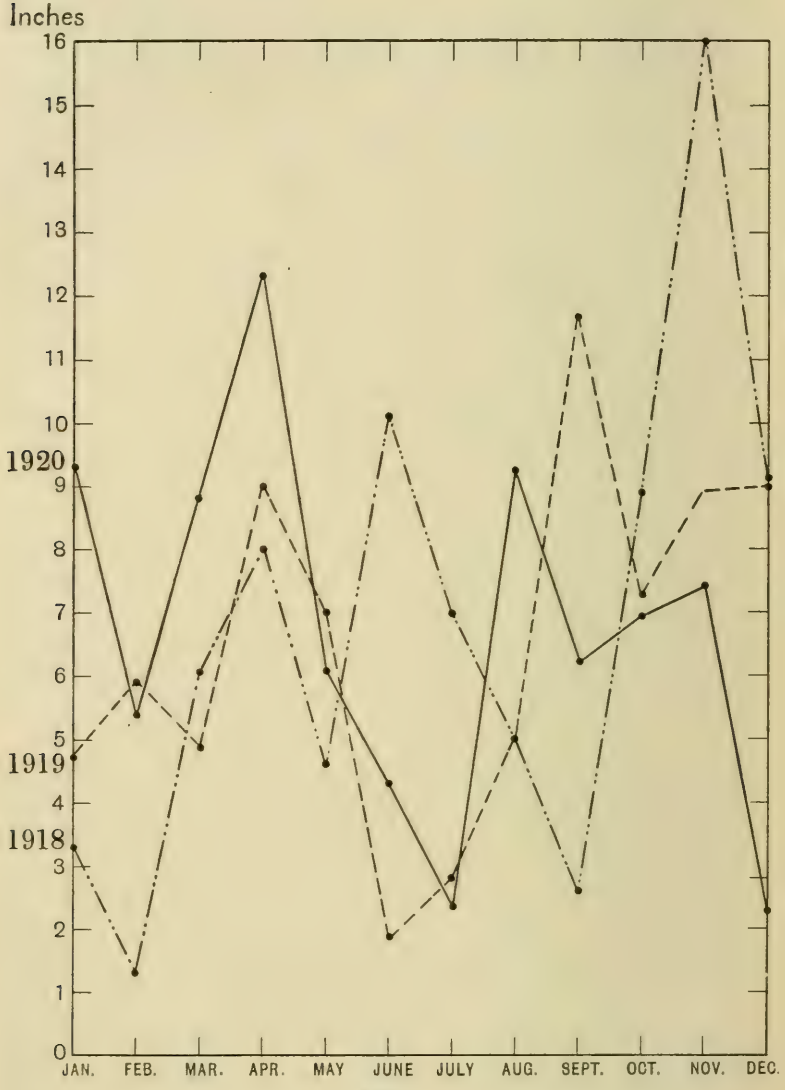


Fig. 1.

Rainfall chart for three years, 1918–20. Jeram District, Selangor.
Total rainfall in inches: 1918 = 82·5, 1919 = 78·7, 1920 = 80·7

Table showing the occurrence of species throughout the year in South Malaya.

	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Ceratiomyxa fruticulosa Macbr.	×	×	×	×		×	×		×	×	×	×
,, ,, var. flexuosa ...		×		×			×	×		×		
Badhamia orbiculata Rex		×		×			×				×	×
,, affinis Rost.											×	
Physarum columbinum (Berk. & Curt.) Sturgis				×							×	
,, psittacinum v. fulvum Lister ...								×				
,, viride Pers.	×	×	×	×				×	×	×	×	×
,, ,, var. aurantium Lister ...									×		×	
,, ,, ,, incanum Lister ...										×		
,, ,, ,, rigidum Lister ...	×	×	×	×		×		×	×	×		×
,, melleum Mass.				×			·			×	×	×
,, auriscalpium Cooke	×			×				×			×	
,, nucleatum Rex		×			×			×			×	
,, compressum Alb. & Schw. ...												
,, nutans Pers.	×											
,, reniforme Lister	×	×		×			×	·				×
,, virescens Ditm....	×											
,, pusillum Lister											×	
,, lateritium Morgan		×										
Fuligo septica Gmelin			×	×				×				×
,, cinerea Morgan	×	×	×									
Erionema aureum Penz.				×				·			×	
Trichamphora pezizoides Jungh.	×		×	×		·		×		×		×
Physarella oblonga Morgan	×	×	×	×	×	×	·	×	×	×	×	×
Cienkowskia reticulata Rost.	×						·					×
Craterium minutum Fries						×						
Diderma effusum Morgan									×			
,, arboreum G. Lister & Petch. ...	×							×	×			×
,, hemisphericum Hornem. ...		×			×							
Diachea leucopoda Rost.				×	×							
Didymium Clavus, Rost.		×	×	×		·			×	×		
,, nigripes Fries											×	
,, leoninum Berk. & Br.											×	
Stemonitis fusca Roth.	×			×			·	×				×
,, splendens Rost.		×		×	×			×		×		
,, ferruginea Ehrenb.	×	×		×	×							×
Comatricha laxa Rost.											×	
,, pulchella Rost.				×							×	
,, typhoides Rost.		×		×							×	×
,, longa Peck	×	×	×	×	×		·	×			×	×
,, irregularis Rex?										×		
Lamproderma arcyrionema Rost....											×	
Cribraria intricata Schrad....			×			·				×	×	
,, var. dictydioides...				×				×				
,, splendens Schrad.												
,, violacea Rex			·	·	·					·	×	
,, microcarpa Pers....						·		×				
Dictydium cancellatum Macbr.			·				·				×	
Tubifera ferruginosa Gmel.				×				×				
,, stipitata Macbr.	×		×							×	×	×
Alwisia Bombarda Berk. & Br.	×			×		×		×		×	×	×
Dictydiaethalium plumbeum Rost. ...		·		×						×		

Table showing the occurrence of species throughout the year in South Malaya (continued).

	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Lycogala epidendrum Fries	×		×	×		×		×	×	×		×
Reticularia Lycoperdon Bull.	×		×	×						×	×	
Trichia affinis de Bary												×
,, persimilis Karst.								×		×		
Hemitrichia Vesparium Macbr.	×											
,, clavata Rost.	×	×	×	×		×		×	×		×	×
,, Serpula Rost.	×	×				×	×					
Arcyria ferruginea Sauter	×	×	×	×				×		×	×	×
,, cinerea Pers.	×	×		×	×	×		×		×	×	×
,, denudata Wettst.	×	×	×	×	×		×	×		×	×	×
,, nutans Grev.	×	×	×	×			×	×	×			×
,, virescens G. Lister		×								×	×	
,, Oerstedtii Rost.											×	
,, insignis Kalchbr.										×		
Perichaena chrysosperma Lister				×					×		×	×
,, depressa Libert		×	×								×	×
,, vermicularis Rost.	×				×						×	×
,, corticalis Rost.												
Margarita metallica Lister											×	

Table showing habitats of Malayan Mycetozoa.

	Recorder	Hevea logs	Coconut palm	Other palms	Dead jungle logs	Living trees	Leaves
Ceratiomyxa fruticulosa ...	S.	×	×		×		
,, ,, var. flexuosa	C., S.	×			×		
Badhamia orbiculata	S.	×	×			×	
,, affinis	S.					×	
Physarum columbinum	S.				×		
,, psittacinum v. fulvum	S.	×					
,, viride	H., S., N., C.	×	×	×	×		×
,, ,, var. aurantium	H., S.	×	×	×		×	
,, ,, ,, incanum ...	S.		×			×	
,, ,, ,, rigidum ...	S.	×			×		
,, melleum	S.	×			×		
,, auriscalpium	S.	×	×			×	
,, nucleatum	H., B., S.	×	×				×
,, compressum	N., B., S.				×		
,, nutans	B.						
,, reniforme	D., B., S.	×	×		×	×	
,, virescens	S.				×		
,, pusillum	S.				×		
,, lateritium	S.				×		
Fuligo septica	S.	×			×		
,, cinerea	S.	×					
Erionema aureum	S.				×		
Trichamphora pezizoides ...	B., S.	×			×		
Physarella oblonga	S., N.	×	×		×		
Cienkowskia reticulata	S.		×	×			×

Table showing habitats of Malayan Mycetozoa (continued).

	Recorder	Hevea logs	Coconut palm	Other palms	Dead jungle logs	Living trees	Leaves
Craterium minutum	S.						×
Diderma effusum...	S.		×				×
,, arboreum	S.	×	×				
,, hemisphericum ...	S.						×
Diachea leucopoda	R., B., S.	×					×
Didymium Clavus	S.						×
,, nigripes	D., S.						×
,, leoninum	B.						×
Stemonitis fusca	H., S., B.	×	×		×		
,, splendens	S.	×			×		
,, ferruginea	S.	×	×	×	×		
,, herbatica	Sp.						
Comatricha laxa	S.	×					
,, pulchella	B., S.						×
,, typhoides	S.	×	×		×		
,, longa	S., Sp.	×			×		
,, irregularis?	S.						
Lamproderma arcyrionema ...	S.				×		
Cribraria intricata	S.	×			×		
,, var. dictydioides ...	Sp., S.				×		
,, splendens	C.				×		
,, violacea	S.		×	×			
,, microcarpa	S.		×		×		
Dictydium cancellatum	S.	×			×		
Tubifera ferruginosa	Sp., S.	×			×		
,, stipitata	S., Sp.	×			×		
Alwisia Bombarda	S.				×		
Dictydiaethalium plumbeum ...	S	×			×		×
Lycogala epidendrum	R., Sp., S.	×			×		
Reticularia Lycoperdon	S.	×			×		
Trichia affinis	S.	×	×		×		×
,, persimilis...	S.	×	×		×		×
Hemitrichia Vesperium	S.				×		
,, clavata	H., S.	×	×	×	×		×
,, Serpula	S.	×	×		×		
Arcyria ferruginea	S.	×			×		
,, cinerea	S.	×	×	×	×	×	×
,, denudata	H., Sp., S.	×		×	×		×
,, nutans	C., S.	×	×		×		
,, virescens...	B., S.				×		
,, Oerstedtii	C.						
,, insignis	S.						×
Perichaena chrysosperma ...	S.				×		
,, depressa	S.	×			×		
,, vermicularis ...	S.	×	×			×	×
,, corticalis	H.						
Margarita metallica	S.	×	×			×	

The initials in the Recorder column refer to the following:

H., Dr G. D. Haviland; B., J. H. Burkill; R., H. N. Ridley; C., F. T. Chipp; Sp., Sappan; N., Noor; S., A. R. Sanderson.

I desire to express my thanks to Miss G. Lister, F.L.S., for examining and identifying many of the specimens, for much kindly help in the preparation of the paper and for seeing it through the printer's hands. I am indebted to Mr F. T. Chipp, F.L.S., for reading over part of the original rough notes and for supplying me with information as regards previous records of Malayan Mycetozoa.

HOMOTHALLISM AND HETEROTHALLISM IN THE GENUS COPRINUS.

By Irene Mounce, M.A. (British Columbia), Hudson's Bay Company Research Fellow, University of Manitoba.

I. Introduction.

In 1918 Mlle Bensaude* brought forward experimental and cytological evidence which appeared to prove that *Coprinus fimetarius* is heterothallic; and in 1919 Hans Kniep†, after making a similar investigation, came to the conclusion that heterothallism is characteristic of *Schizophyllum commune* and of a number of other Hymenomycetes.

In 1921, in a paper published in these Transactions, I recorded that clamp-connections had regularly appeared in mycelia of monosporous origin in *Coprinus sterquilinus*, *C. stercorarius*, *C. lagopus* and *C. niveus*, and that I had therefore come to the conclusion that all these four species are homothallic‡. This paper was sent to England for publication in May 1921. The following autumn, on resuming my investigations, I made a large number of monosporous cultures of *Coprinus lagopus* but found to my surprise that in not a single one of them did any clamp-connections make their appearance. The spore-deposits used for making the cultures described in my previous paper had been destroyed, so that it was unfortunately impossible to investigate them again. The spores in my new cultures, therefore, had a different origin from those previously employed. Suspecting that the strains of the fungus used in my new investigation were heterothallic, I tried the effect of pairing the mycelia. The results of this operation were similar to those

* Mathilde Bensaude, Recherches sur le cycle évolutif et la sexualité chez les Basidiomycètes, Nemours, 1918, pp. 1–156.

† Hans Kniep, Über morphologische und physiologische Geschlechtsdifferenzierung, Verhandl. der Physikal.-med. Gesells. zu Wurzburg, 1919, pp. 1–18.

‡ Irene Mounce, Homothallism and the Production of Fruit-bodies by Monosporous Mycelia in the Genus Coprinus, Trans. Brit. Mycolog. Soc. VII, 1921, pp. 198–217.

obtained by Mlle Bensaude and Hans Kniep; certain pairs of mycelia produced clamp-connections in large numbers and others never produced any clamp-connections at all. Moreover, the pairs of mycelia which produced clamp-connections gave rise to perfect fruit-bodies, whilst those pairs which did not produce clamp-connections gave rise only to imperfect fruit-bodies. I therefore came to the conclusion that the strains of *Coprinus lagopus* used for my new investigation were heterothallic. It then seemed highly desirable that I should re-investigate the mycelia of *Coprinus sterquilinus*, *C. stercorarius* and *C. niveus*. I therefore made a new series of cultures for each of these species. With *Coprinus sterquilinus* and *C. stercorarius*, I obtained results exactly similar to those already recorded: clamp-connections appeared regularly on all the mycelia of monosporous origin. My conclusion that these two species are homothallic was therefore confirmed and strengthened. With *Coprinus niveus*, just as with *C. lagopus*, I found that in a series of monosporous cultures not a single mycelium gave rise to clamp-connections but that, on pairing the mycelia, some pairs produced clamp-connections abundantly and some pairs no clamp-connections whatever. I have therefore convinced myself that the strain of *Coprinus niveus* used for my new investigation is heterothallic.

The object of this paper is to bring forward further evidence in support of my previous conclusion that *Coprinus sterquilinus* and *C. stercorarius* are homothallic and to show that *Coprinus lagopus* and *C. niveus* are not always homothallic, as I at first believed, but are often, and perhaps as a rule, heterothallic*.

II. Criteria of Sex.

This paper is to be regarded as a continuation of the one already published. Here, therefore, it will not be necessary to discuss the criteria for distinguishing a homothallic species of *Coprinus* from a heterothallic one in detail; and it will be sufficient for our present purpose to remind the reader of the following facts. Mlle Bensaude and Hans Kniep, working independently, have shown that the presence of clamp-connections on a mycelium is associated with dicaryons and the conjugate division of the nuclei. Clamp-connections, therefore, are an outward and visible sign that the mycelium on which they arise is in the diploid and not the haploid condition. A species of *Coprinus* producing clamp-connections is *homothallic* if clamp-

* These results were communicated to the Mycological Section of the American Botanical Society at the Toronto meeting of the American Association for the Advancement of Science, December, 1921, in a paper entitled: "Homothallism and Heterothallism in the Genus Coprinus"; but no abstract of this paper has been published.

connections are regularly formed on mycelia of monosporous origin, or if clamp-connections are formed on compound mycelia arising from spores all of which have been derived from a single fruit-body produced from a mycelium of monosporous origin. A species of Coprinus producing clamp-connections is *heterothallic* if clamp-connections are *not* formed on mycelia of monosporous origin but only upon compound mycelia produced by the union of two monosporous mycelia presumably of opposite sex.

Mlle Bensaude, working with *Coprinus fimetarius*, came to the conclusion that, in a heterothallic species, monosporous mycelia are always sterile. However, Kniep has discovered that, in *Schizophyllum commune* and certain other species of Hymenomycetes which are heterothallic, fruit-bodies sometimes appear on mycelia of monosporous origin and of haploid nature, one nucleus finally entering each basidium instead of two. Fruit-body production in a heterothallic species, therefore, is not necessarily bound up with the diploid condition of the mycelium; so that if, on experimenting with a new species, one finds that a fruit-body is produced on a monosporous mycelium, one is not justified by that fact alone in regarding the species as homothallic. Nevertheless, from my own experience with heterothallic strains of *Coprinus lagopus* and *C. niveus*, Mlle Bensaude's experience with *Coprinus fimetarius*, and Kniep's experience with *Schizophyllum commune*, I am of the opinion that, in a heterothallic species, fruiting takes place either not at all or much less readily and less perfectly on a monosporous mycelium than on a compound mycelium formed by the union of two mycelia presumably of opposite sex.

III. Methods.

The isolation of mycelia of monosporous origin by plating out spores in dung agar was accomplished in the manner already described in my first paper. However, owing to the provision of a new and improved autoclave, the culture medium was sterilised at 15 pounds pressure instead of 7 pounds.

The pairing of mycelia of monosporous origin in the tests for heterothallism was effected as follows. The monosporous mycelia were first grown separately upon dung-agar plates or in wide test-tubes containing horse dung, and then portions of the mycelia were placed in pairs on dung-agar plates. In making an inoculation from two plate cultures, a small piece of mycelium-covered agar about 7–10 mm. square was removed by means of a sterile platinum loop from each of two plates, and these two pieces of agar were placed about 2 cm. apart in the middle of a freshly-poured dung-agar plate. In making an inoculation

from two dung-tubes, the procedure was the same, except for the fact that the two pieces of mycelium-covered dung were removed from the tubes by means of sterilised forceps instead of by a platinum loop.

After portions of two monosporous mycelia had been deposited near one another in an agar plate, the hyphae soon began to grow radially outwards through the agar; and, after a few days, the hyphae of the two mycelia came into contact in a line passing through the centre of the plate, so that fusions could take place between them. At the end of 7–14 days from pairing, the compound mycelium was examined under the high power of the microscope for the presence or absence of clamp-connections.

In the heterothallic strains of *Coprinus lagopus* and of *C. niveus*, a primary (haploid) mycelium differs from a secondary (diploid) mycelium in several ways. (1) A primary mycelium produces oidia in great abundance but a secondary does not. (2) A primary mycelium does not bear clamp-connections, whereas a secondary one does on all the stouter hyphae. (3) The branching of a primary mycelium is relatively irregular, whereas in a secondary mycelium it takes place on all the leading hyphae at a definite angle. (4) It was also noticed that in a primary mycelium the aerial hyphae are more abundant and, therefore, collectively, are more woolly in appearance than in a secondary mycelium. Owing to these differences between a primary and a secondary mycelium, one could usually tell macroscopically, 7–14 days after pairing, whether the sexes of any two paired mycelia were the same or different. Microscopic observation as to the presence or absence of clamp-connections, therefore, usually confirmed what had been surmised by examination with the naked eye.

IV. *Coprinus sterquilinus.*

The series of monosporous cultures of *Coprinus sterquilinus* of which I gave an account in my first paper has been extended, and now fruit-bodies have been obtained from monosporous mycelia for seven successive generations. When grown under similar conditions, the mycelia of the seventh monosporous generation were found to fruit just as readily and as perfectly as compound mycelia derived from many spores of a wild fruit-body.

Clamp-connections were found in the new cultures: (1) on each of two mycelia which originated from single spores produced by a fruit-body of the sixth successive monosporous generation, and (2) on each of four mycelia which originated from single spores produced by a fruit-body of the seventh successive monosporous generation. These results are in complete accord with those given in my first paper.

The additional facts just described, which again show that monosporous mycelia produce clamp-connections and fruit readily and perfectly, afford strong confirmatory evidence of the correctness of the conclusion to which I came in my first paper, namely, that *Coprinus sterquilinus* is homothallic.

V. *Coprinus stercorarius.*

In a new series of monosporous cultures of *Coprinus stercorarius*, clamp-connections were formed: (1) on each of three mycelia which originated from single spores of a wild fruit-body, and (2) on each of six mycelia which originated from single spores produced by a fruit-body of monosporous origin. All these nine mycelia produced clamp-connections two days after isolation and transference to a new plate. They therefore behaved exactly like the monosporous mycelia described in my first paper.

Three of the mycelia of the second series (2) were allowed to continue their development on dung-agar plates, and there they produced small perfect fruit-bodies which shed spores. It thus was proved that monosporous mycelia of *Coprinus stercorarius*, even of the second monosporous generation, are able to fruit in a perfectly normal manner.

The additional facts just described, which again show that monosporous mycelia produce clamp-connections and fruit readily and perfectly, afford strong confirmatory evidence of the correctness of the conclusion to which I came in my first paper, namely that *Coprinus stercorarius* is homothallic.

Brefeld* shows clamp-connections as occurring on a monosporous mycelium of *C. stercorarius*. His observations and my own are therefore in accord. On the other hand, Kniep†, without giving details of his evidence, states that this fungus is heterothallic. It is, therefore, possible that there may be in existence both homothallic and heterothallic strains of *C. stercorarius*. Further experiment with diverse strains obtained from different localities can alone teach us the truth about this matter.

VI. *Coprinus lagopus.*

In the series of experiments upon *Coprinus lagopus* recorded in my first paper I found that clamp-connections developed: (1) on each of several mycelia of monosporous origin derived from the spores of a wild fruit-body, (2) on each of three mycelia of monosporous origin derived from spores produced by a fruit-body of monosporous origin, and (3) on a compound mycelium

* O. Brefeld, Untersuchungen, Leipzig, Heft III, 1877, p. 206 under Fig. 3 *b*; also Taf. I, Fig. 3 *b*.

† Hans Kniep, *loc. cit.* p. 13.

of polysporous origin derived from many spores produced by a fruit-body of monosporous origin. I therefore came to the conclusion that *C. lagopus* is homothallic. There was nothing to suggest that this species might be heterothallic.

After sending my first paper to the press in May 1921, I isolated another series of monosporous mycelia of *C. lagopus* and, as I was leaving Winnipeg for Vancouver, took the cultures with me. To my great surprise, I found that these mycelia did not produce any clamp-connections. During the summer of 1921, circumstances prevented me from making any further experiments; but, on returning to Winnipeg in September, I at once began to investigate *Coprinus lagopus* again with the object of solving the problem of the sex of the mycelia in this species.

Altogether, since writing my first paper, I have made 59 new monosporous cultures of *C. lagopus*. Owing to the fact that some of the spore-deposits of *C. lagopus* had been destroyed after the completion of my first paper, I was compelled to use new spore material. The new spores were provided by ten different fruit-bodies. To the best of my knowledge the mycelia were isolated in exactly the same manner as formerly. They were all transferred to agar plates and, later, 29 of them were transferred to sterilised dung in wide test-tubes; and they were all kept in pure culture for 50 days and most of them for from two to three months. Examination with the microscope yielded a result just the opposite of that found in the experiments recorded in my first paper, for not a single one of all the 59 monosporous mycelia produced any clamp-connections whatever. On the other hand, polysporous mycelia derived from several spores produced clamp-connections within four or five days after the spores were sown.

These new observations naturally suggested that the strains of *Coprinus lagopus* with which I was working were heterothallic. Therefore, assuming that the monosporous mycelia were all unisexual and would behave in the same manner as Blakeslee's (+) and (−) strains of Mucor and as Mlle Bensaude's (+) and (−) strains of her *Coprinus fimetarius*, I paired 23 of the mycelia with No. 14 and 7 with No. 46, Nos. 14 and 46 being taken as standards. The results of making these 30 pairs are shown in Table I. In the fourth column of this table the blanks indicate that no observations with regard to fruiting were recorded.

Of the 30 pairs of mycelia, 17 developed clamp-connections in a regular manner, while 13 did not develop any clamp-connections whatever. It was therefore supposed that a (+) and a (−) sexual strain must have been present in each of the

Table I. Coprinus lagopus: *The Effect of Pairing Monosporous Mycelia.*

Mycelial pairs	Sexual signs	Clamp-connections 4–7 days after pairing	Fruit-body development in the plates
3 × 14	+ +	absent	imperfect
4 × 14	+ +	,,	,,
6 × 14	+ +	,,	,,
7 × 14	+ +	,,	,,
9 × 14	+ +	,,	,,
10 × 14	− +	present	perfect
11 × 14	− +	,,	—
12 × 14	− +	,,	perfect
13 × 14	+ +	absent	—
15 × 14	+ +	,,	imperfect
16 × 14	+ +	,,	,,
17 × 14	+ +	,,	,,
18 × 14	− +	present	perfect
19 × 14	− +	,,	,,
20 × 14	− +	,,	,,
21 × 14	+ +	absent	imperfect
22 × 14	+ +	,,	,,
23 × 14	− +	present	perfect
25 × 14	− +	,,	,,
26 × 14	− +	,,	,,
27 × 14	− +	,,	,,
28 × 14	− +	,,	,,
29 × 14	− +	,,	,,
47 × 46	− −	absent	—
48 × 46	− −	,,	—
51 × 46	+ −	present	—
52 × 46	+ −	,,	—
53 × 46	+ −	,,	—
54 × 46	+ −	,,	—
55 × 46	+ −	,,	—

17 pairs in which clamp-connections had appeared. No. 14 was given a (+) sign, but this was done quite arbitrarily, for morphologically No. 14 did not differ from the other mycelia. The mycelia with which No. 14 had produced clamp-connections were then given a (−) sign, and the mycelia with which No. 14 had not produced clamp-connections were given a (+) sign. Subsequently it was found that clamp-connections were formed when No. 46 was mated with No. 14. Since No. 14 had a (+) sign, it was therefore necessary to give No. 46 a (−) sign. Nos. 51–55 all produced clamp-connections with No. 46. Hence they were given a (+) sign; and, since Nos. 47 and 48 did not yield clamp-connections with No. 46, they were given a (−) sign. All these signs are shown in Table I.

The pairs of mycelia which developed clamp-connections also developed normal fruit-bodies. About a week after the matings had been effected, these fruit-bodies expanded and shed an abundance of their black spores. On the contrary, the pairs of mycelia which remained in the primary condition and did not

develop clamp-connections, gave rise only to imperfect fruit-bodies. These varied from about the size of a pin's head to rudiments 3–4 mm. high. In the larger rudiments, the stipe and pileus were clearly differentiated, but no expansion took place and no spores were ever liberated. It was therefore clear that rapid and perfect production of fruit-bodies was associated in my cultures with the formation of clamp-connections, i.e. with the secondary or diploid condition of the mycelium, and that the production of imperfect fruit-bodies was associated with the non-formation of clamp-connections, i.e. with the primary or haploid condition of the mycelium.

After the results embodied in Table I had been obtained, it was to be expected that mycelia of like signs, if paired, would not produce any clamp-connections. Each of six plates was therefore inoculated with two mycelia of (+) sign, and each of 18 plates with two mycelia of (−) sign. The results of this pairing, which are shown in Table II, did not conform with expectation, for only 16 of the 24 pairs remained without clamp-connections, while clamp-connections soon made their appearance in one of the six (++) pairs and in 7 of the 18 (−−) pairs. It therefore became apparent that the phenomenon of heterothallism in *Coprinus lagopus* is much more complicated than I had at first imagined.

Table II. Coprinus lagopus: *The Effect of Pairing Monosporous Mycelia of Like Sign.*

Mycelial pairs	Sexual signs	Clamp-connections after pairing	Fruit-body development in the plates
15 × 16	+ +	absent	—
16 × 17	+ +	,,	—
17 × 21	+ +	,,	—
21 × 22	+ +	,,	—
27 × 28	− −	,,	—
23 × 26	− −	present	—
28 × 19	− −	absent	—
25 × 46	− −	,,	—
48 × 47	− −	,,	—
18 × 47	− −	present	—
51 × 15	+ +	absent	—
55 × 16	+ +	present	—
23 × 18	− −	,,	perfect
23 × 19	− −	,,	,,
23 × 25	− −	absent	imperfect
23 × 27	− −	,,	,,
23 × 28	− −	,,	,,
23 × 29	− −	,,	,,
26 × 18	− −	present	perfect
26 × 19	− −	,,	,,
26 × 25	− −	absent	imperfect
26 × 27	− −	present	perfect
26 × 28	− −	absent	imperfect
26 × 29	− −	,,	,,

On the strict (+) and (−) theory of sex, one would suppose that if a mycelium *a* were to yield clamp-connections when paired with either *b* or *c*, the sex of the mycelia *b* and *c* would be identical; so that, if *b* and *c* were to be paired, no clamp-connections would be formed. But this is not always the case, for sometimes we may have clamp-connections developed in all the pairs $a \times b$, $a \times c$ and $b \times c$. Thus, as shown in Table I, mycelium No. 14 forms clamp-connections with both Nos. 23 and 26; but the mycelia Nos. 23 and 26 are not identical in sex, for, as shown in Table II, when paired, they yield clamp-connections. With four mycelia instead of three, even greater complications may arise. It thus appears that the factors or genes for sex in *Coprinus lagopus* are not of a simple but of a compound nature.

In the fourth column of Table II are given the results of observation of fruit-body production for 12 (− −) pairs of mycelia. Here again, as in the experiments recorded in Table I, rapid and perfect production of fruit-bodies was associated always with the production of clamp-connections, i.e. with the secondary or diploid condition of the mycelium, while the production of imperfect fruit-bodies was associated always with the absence of clamp-connections and the retention by the mycelium of the primary or haploid condition.

As a result of the experiments which have just been described it became necessary to discard the strict (+) and (−) theory of sexual strains for *C. lagopus*.

Table III shows the results that were actually obtained when seven monosporous mycelia were paired in all the possible ways. In this table, for the sake of conformity with similar tables made by Kniep for *Schizophyllum commune*, the (+) and (−) signs are introduced, but here they have not the same significance as in Tables I and II, for they do not indicate sex but merely the presence (+) or absence (−) of clamp-connections in the pairs.

Table III. Coprinus lagopus: *All Possible Pairings of Seven Monosporous Mycelia.*

	21	22	23	25	26	27	29
21	−	−	+	+	+	+	+
22	−	−	+	−	+	+	+
23	+	+	−	−	+	−	−
25	+	−	−	−	−	−	+
26	+	+	+	−	−	+	−
27	+	+	−	−	+	−	−
29	+	+	−	+	−	−	−

When the experiments recorded in Table III were being made, a check upon the purity of the seven monosporous mycelia was

obtained by setting out portions of the mycelia in plates by themselves. In none of these sub-cultures were clamp-connections ever produced.

Since, as indicated in Table I, Nos. 23, 25, 26, 27 and 29 all produced clamp-connections with No. 14, it was to be expected on the strict (+) and (−) theory of sex that they would all behave uniformly with respect to other mycelia; but, by looking along the horizontal rows in Table III, it will be at once seen that this expectation was not justified by experience. Thus although with No. 21 they all gave clamp-connections, yet with Nos. 22, 23 and 25 they did not all behave uniformly; for with No. 22 they all produced clamp-connections except No. 25, with No. 23 they none of them produced clamp-connections except No. 26, and with No. 25 they none of them produced clamp-connections except No. 29.

The results given in Table III are identical in their nature with those obtained by Hans Kniep with *Schizophyllum commune**.

VII. *Coprinus niveus.*

In the series of experiments upon *Coprinus niveus* recorded in my first paper, I found that clamp-connections developed: (1) on each of several mycelia of monosporous origin derived from the spores of a wild fruit-body, (2) on each of two monosporous mycelia derived from spores produced by a fruit-body of monosporous origin, and (3) on a compound mycelium of polysporous origin derived from many spores produced by a fruit-body of monosporous origin. I therefore came to the conclusion that *Coprinus niveus* is homothallic.

In the winter of 1921–22, I made a new series of experiments which yielded results quite different from those previously obtained. The source of the spores was a wild fruit-body which came up spontaneously on horse dung in the laboratory.

Nine monosporous mycelia were isolated and transferred to dung-agar plates and afterwards sub-cultured in other plates; but, even after the lapse of 32 days, they all failed to produce clamp-connections. On the other hand, a compound mycelium of polysporous origin derived from many spores produced clamp connections in abundance ten days after inoculation.

The presence of clamp-connections on the mycelium of polysporous origin and their absence from the nine mycelia of monosporous origin at once suggested that my new strain of *Coprinus niveus* was heterothallic. A complete series of crossings with the nine mycelia was therefore undertaken. The results are shown in Table IV. As before, the numbers above and to

* H. Kniep, *loc. cit.* p. 12.

the left indicate the numbers given to individual mycelia, while the (+) and (−) signs indicate that clamp-connections were present or absent respectively after the crossings had been effected.

Table IV. Coprinus niveus: *All Possible Pairings of Nine Monosporous Mycelia.*

	1	2	3	4	5	6	7	8	9
1	−	−	−	+	−	−	−	−	−
2	−	−	−	−	−	−	+	+	+
3	−	−	−	+	−	−	−	−	−
4	+	−	+	−	+	+	−	−	−
5	−	−	−	+	−	−	−	−	−
6	−	−	−	+	−	−	−	−	−
7	−	+	−	−	−	−	−	−	−
8	−	+	−	−	−	−	−	−	−
9	−	+	−	−	−	−	−	−	−

As is shown in Table IV, Nos. 2 and 3 both failed to form clamp-connections with Nos. 1, 2, 3, 5 and 6. Yet they are not identical sexually, for No. 2 formed clamp-connections with Nos. 7, 8 and 9, whereas No. 3 did not. Similarly Nos. 4 and 5 did not form clamp-connections with Nos. 2, 7, 8 and 9 and yet are not identical sexually, for No. 4 formed clamp-connections with Nos. 1, 3, 5 and 6, whereas No. 5 did not. Moreover, when Nos. 4 and 5 were paired, they yielded clamp-connections. That the monosporous mycelia were pure was ascertained by making sub-cultures of these mycelia in plates at the same time that the pairings were effected. In none of these nine sub-cultures did any clamp-connections make their appearance. This is indicated in Table IV by the (−) sign for 1 × 1, 2 × 2, 3 × 3 ... 9 × 9.

The results embodied in Table IV seem to show conclusively that the strain of *Coprinus niveus* with which my new work has been carried out is heterothallic but that the individual mycelia cannot be regarded as belonging strictly to two opposite strains, (+) and (−). Thus in my new work *C. niveus* has behaved sexually in the same manner as *C. lagopus*.

VIII. Discussion.

In both of my investigations upon the sex of *Coprinus sterquilinus* and *C. stercorarius*, mycelia of monosporous origin yielded clamp-connections regularly and readily gave rise to normal fruit-bodies. All the evidence so far obtained therefore strongly supports the view already expressed in my first paper, namely, that *Coprinus sterquilinus* and *C. stercorarius* are homothallic.

So far as concerns *Coprinus lagopus* and *C. niveus*, the results of my two investigations are discordant; for, in the first, monosporous mycelia gave rise regularly to clamp-connections whilst, in the second (described in this paper), clamp-connections never appeared in monosporous mycelia (59 isolations for *C. lagopus* and 9 for *C. niveus*) but only after the pairing of two monosporous mycelia presumably of opposite sex. My first investigation therefore led me to believe that *Coprinus lagopus* and *C. niveus* are homothallic, whereas my second one has provided conclusive evidence that there are strains of both these fungi which are heterothallic.

It may be asked: admitting that all the new observations go to show that *Coprinus lagopus* and *C. niveus* are heterothallic, how is it that different results pointing to homothallism were obtained in the first investigation? There appear to be two alternative explanations: (1) in my first investigation some error crept into the work, (2) there are homothallic strains of both these fungi as well as heterothallic.

I have not been able to think of a single source of error in my first work that could account for the results obtained. So far as I know, I used the same method for isolating and cultivating the mycelia for my second investigation as for my first. I do not think that the plates became infected by spores from the air, or that I confused species or spore-deposits; and I certainly saw the clamp-connections described, for I sketched some of them with the camera-lucida. If I made some mistake in method, I must have repeated it quite consistently in every one of my first experiments, for all the results were consistent, all the monosporous mycelia having produced clamp-connections, and I must have avoided this error consistently in my second experiments, for no clamp-connections ever made their appearance in the 68 new monosporous cultures. On the other hand, it is to be remembered that my first investigation was chiefly devoted to the fruiting of monosporous mycelia, that the question of the presence or absence of clamp-connections was taken up only toward its conclusion, and that the number of observations was relatively few. It is also noteworthy that in my second series of experiments with *Coprinus lagopus*, although I used ten different fruit-bodies, I was unable to obtain any more homothallic strains, and therefore at no time have I been able to grow simultaneously homothallic and heterothallic strains of this fungus.

Blakeslee* found that, in the heterothallic Mucors, each monosporous mycelium is either (+) or (−), and that in these

* A. F. Blakeslee, Sexual Dimorphism in Cunninghamella, Botanical Gazette, LXXII, 1921, p. 186.

fungi there is an absence of sexual intergrades. Kniep*, on the other hand, working with *Schizophyllum commune*, found that, while the monosporous mycelia of this fungus usually are unisexual and do not produce clamp-connections, yet occasionally, when kept in pure culture for a long time, a monosporous mycelium may begin to produce clamp-connections and thus pass definitely from the haploid to the diploid condition. Thus we can speak of *Schizophyllum commune* as being heterothallic but as sometimes producing homothallic strains.

Owing to the fact that I am unable to explain my first results on the basis of error in experiment or observation, and taking into account Kniep's work upon *Schizophyllum commune*, it seems difficult to escape the conclusion that in my first investigation I was studying strains of *Coprinus lagopus* and *C. niveus* which were homothallic. On the other hand, my later results, described in this paper, certainly point to the possibility of some error having occurred in my earlier work. I think, therefore, that it is advisable to lay most weight on my second investigation and to conclude that, while *Coprinus lagopus* and *C. niveus* are undoubtedly heterothallic, it is possible that homothallic strains of both these species exist. The question of the existence or non-existence of these homothallic strains will doubtless be decided by future workers.

In finding that the strict (+) and (−) theory of sex is inapplicable to *Coprinus lagopus* and *C. niveus*, I have but confirmed what Hans Kniep discovered in *Schizophyllum commune*. His table for the latter fungus and my Tables III and IV for the two Coprini are identical in general form.

There can be no doubt that in such fungi as *Schizophyllum commune, Coprinus lagopus* and *C. niveus*, the factors or genes for sex are not simple but complex in their nature. To what extent this applies to the Hymenomycetes in general can only be determined by new and extensive investigations.

Recently, B. O. Dodge† working with *Ascobolus magnificus* has found that, so far as sex-organs and ascocarps are concerned, monosporous mycelia are self-sterile, but that sexual organs and ascocarps are produced in cultures containing two strains properly chosen. It thus appears that there are heterothallic species not only in the Basidiomycetes but also in the Ascomycetes.

In my first paper, I pointed out that the *Coprinus fimetarius* used by Mlle Bensaude and my own *C. lagopus* might be identical species. I now think them to be identical and shall so regard them in future. Mlle Bensaude worked with only two mono-

* H. Kniep, *loc. cit.* p. 16.

† B. O. Dodge, The Life History of *Ascobolus magnificus*; Origin of the Ascocarp from two Strains, Mycologia, XII, 1920, pp. 115–134.

sporous strains of her fungus. When grown separately, they did not produce clamp-connections and remained sterile; when paired, they produced clamp-connections and fruited well. She therefore regarded them as (+) and (−) strains; but, had she used more sexual strains, she no doubt would have found out how complex sex is in this fungus and also that the strict (+) and (−) theory of sex is here inapplicable. In my experiments, the development of rudimentary fruit-bodies on monosporous mycelia has been very variable. However, it is somewhat remarkable that Mlle Bensaude's two sexual strains, when grown separately, remained entirely sterile.

IX. Conclusions.

1. *Coprinus sterquilinus* and *C. stercorarius*, as shown by the production of clamp-connections and fruit-bodies in monosporous cultures, are homothallic.

2. *Coprinus sterquilinus* has been successfully cultivated with the production of perfect fruit-bodies for seven successive monosporous generations. The mycelium of the seventh generation was just as vigorous and fruited just as rapidly as the mycelium of the first generation.

3. There are heterothallic strains of *Coprinus lagopus* and *C. niveus*. Fifty-nine monosporous mycelia of *C. lagopus*, grown separately, never produced clamp-connections. When brought together in suitable pairs, the monosporous mycelia soon produced clamp-connections and later perfect fruit-bodies. Similar results were obtained with nine monosporous mycelia of *C. niveus*.

4. *Coprinus lagopus* and *C. niveus* are heterothallic species; but, as indicated by previous experiments, it is possible that they both sometimes give rise to homothallic strains.

5. The question of sex in heterothallic Coprini is complicated by the fact that the sexual strains cannot be strictly divided into (+) and (−) groups.

6. The sexual reactions between the monosporous mycelia in *Coprinus lagopus*, or in *C. niveus*, are similar to those described by Kniep for *Schizophyllum commune*.

The investigations recorded above were carried out in the Botanical Department of the University of Manitoba during my tenure of the Hudson's Bay Company Research Fellowship. In conclusion, I desire to express my sincere thanks to Professor A. H. Reginald Buller for his continued encouragement and valuable advice.

SLUGS AS MYCOPHAGISTS.

By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.

Introduction.

Slugs eat many fleshy fungi; and in woods and gardens one can often find fruit-bodies which have been more or less damaged by these animals. Fungi, therefore, especially in certain localities and in certain seasons, must be considered as an important source of slug food. Among the fungi which slugs attack may be mentioned: species of Amanita, Pleurotus, Russula, Psalliota, Coprinus, Boletus, Polyporus and Phallus. Leathery fungi, e.g. *Polystictus versicolor*, *Stereum hirsutum* and *Schizophyllum commune*, and gelatinous fungi, e.g. *Hirneola auricula-Judae* and *Auricularia mesenterica*, are generally avoided*.

A fruit-body which has been partially eaten by a slug can be easily recognised: (1) by the peculiar manner in which it has been rasped and mined, and (2) by the slug's slime tracks. Slugs are nocturnal animals. During the day, they hide under soil or in dark crevices; but, as darkness comes on, they emerge from their places of concealment and seek their food. They therefore visit the fruit-bodies of fungi during the night, but, as a rule, retire from them with the advent of day. Sometimes, however, a slug which has made a hole on the under side of the pileus or in the top of the upper part of the stipe of a large agaric, such as *Boletus luteus* or *Lactarius piperatus*, remains half-hidden in the hole throughout the day and then may be found by the observer.

Slug-damaged Fungi in an English Wood.

On September 8, 1920, accompanied by Mr W. B. Grove, I spent an afternoon in a wood at Earlswood, near Birmingham, England, investigating the damage which the slugs had done to the fungi. Out of several hundreds of fruit-bodies of fleshy Hymenomycetes observed, I found very few which had not been visited and partially eaten by slugs. Some of the fruit-bodies had been absolutely ruined by these animals. Thus the stipe of a large *Boletus flavus* had been eaten in two; and the separated pileus had completely lost all its hymenial tubes, whilst the pileus-flesh had become reduced to a thin perforated shell. A slug was found ensconced in one of the cavities of the flesh; and, doubtless, it was only waiting for the night to sate its voracious appetite once more upon the wreck to which it was

* A few experiments upon the edibility of fungi for slugs are recorded in my Researches on Fungi, 1, 1909, p. 229.

clinging. Some other fruit-bodies, e.g. *Russula ochroleuca*, *Lactarius piperatus* and *L. turpis*, were almost equally damaged. The following species were found to have been visited and partially eaten by slugs:

Species attacked by Slugs.

Amanita rubescens.	Laccaria laccata.
Amanitopsis vaginata.	Hypholoma fasciculare.
Clitocybe clavipes.	H. sublateritium.
Russula emetica.	Flammula sapinea.
R. ochroleuca.	Paxillus involutus.
R. sardonia.	Cortinarius anomalus.
R. heterophylla.	C. paleaceus.
R. nigricans.	C. caninus.
R. adusta.	C. rigidus.
Lactarius piperatus.	Boletus flavus.
L. subdulcis.	B. chrysenteron.
L. glyciosmus.	B. scaber.
L. turpis.	Clavaria cinerea.

The following species were found not to have been eaten by slugs:

Species not attacked by Slugs.

Lactarius quietus.	Inocybe geophylla.
L. rufus.	Tubaria furfuracea.
Collybia butyracea.	Cortinarius sanguineus.
Flammula inopus.	Polystictus versicolor.
Inocybe asterospora.	Lycoperdon pyriforme.

Of the species attacked, some, e.g. the Russulae, were damaged much more than others. Scarcely a single fruit-body of any species of Russula could be found which had not been partially eaten. Very few of the fruit-bodies of *Hypholoma fasciculare*, *Laccaria laccata* and *Lactarius glyciosmus* had been eaten and these only slightly, so that it seems that slugs do not much relish these species.

Of the species not attacked by slugs only single fruit-bodies were found of *Flammula inopus*, *Inocybe asterospora* and *Cortinarius sanguineus*, and a few fruit-bodies only of the relatively tiny *Inocybe geophylla* and *Tubaria furfuracea*, so that it is possible that, if the fruit-bodies of these fungi had been more numerous, some of them might have been found attacked. The species which seemed to have been definitely avoided by slugs were *Lactarius quietus*, *L. rufus*, *Collybia butyracea*, *Polystictus versicolor* and *Lycoperdon pyriforme**.

Two species of slugs were found upon the fungi, a larger

* These five species are also distasteful to human beings.

reddish one about one inch long and a smaller darker one. Mr P. T. Deakin kindly identified the former as *Arion subfuscus* var. *aurantiaca* and the latter as a Limax. The specimens submitted for the Limax were too immature for exact identification.

Polystictus versicolor, *Stereum hirsutum*, and other tough and leathery fungi, are probably protected against the ravages of slugs by their physical consistence; while *Lactarius quietus*, *L. rufus*, *L. glyciosmus*, *Collybia butyracea*, *Laccaria laccata* and *Lycoperdon pyriforme* are more or less protected against slugs by their chemical contents. The majority of fleshy fungi, however, seem to be in no way protected against slugs, and some of the commonest species, e.g. those of Russula, Amanita, Amanitopsis and Boletus, often suffer most. On the whole, the very soft-fleshed species seem to be the most relished by slugs, and these animals are particularly fond of the soft parenchymatous tissues of the Lactarii and of the soft hymenial tubes and flesh of many Boleti. Voglino has supposed that slugs are important agents in bringing about the dissemination and germination of the spores of Russulae, etc., and is inclined to believe in the existence of symbiotic relations between slugs and Hymenomycetes*. I am rather of the opinion that, when a slug attacks a fruit-body, the advantage is chiefly, if not entirely, on the side of the slug and that, from the point of view of the fungus, the slug is a troublesome ectoparasite. As I have pointed out elsewhere, the fruit-bodies of the Hymenomycetes are beautifully organised to secure the dissemination of the spores by the wind and their injury by slugs certainly prevents a great many spores from being liberated†.

Absence of Slugs from a Wood in Central Canada.

In the late autumn of 1920, I spent several days at Kenora on the Lake of the Woods, central Canada, studying the fleshy fungi in the woods; and, although I made a careful search, I could not find a single agaric damaged by a slug.

Slugs, which are common in England and in the extreme west of Canada (British Columbia), where the climate is damp and moderately warm, are rare in central Canada, where the climate is very dry and relatively cold. Most native-born Manitobans, so far as I can find out by enquiry, have never seen a living slug; and there can be no doubt that the big species of Limax, Arion, etc., which abound in gardens and woods in England, are entirely absent from central Canada. Nevertheless, Mr J. W. Wallis of Winnipeg has assured me that he once found some small slugs living wild in the open in Manitoba; and I, myself,

* Cf. my Researches on Fungi, 1, 1909, pp. 226–227.
† *Ibid.* p. 228.

have seen one small slug in a greenhouse at Winnipeg. However, I have never yet seen a slug in any of the woods of central Canada.

Since fleshy fungi, e.g. Russulae, Lactarii, Amanitae, Cortinarii, etc., occur in great variety and numbers in the woods of central Canada, and since slugs do not occur in these woods or are very rare there, it seems safe to infer that fleshy fungi, such as Russulae, Lactarii, Amanitae, Cortinarii, etc., in no way depend upon slugs for the dissemination or germination of their spores.

Some Conclusions.

We may conclude from the above observations: (1) that slugs, under natural conditions, may attack and feed upon most species of fleshy Hymenomycetes occurring in woods, (2) that the attacks of the slugs often seriously interfere with the production and liberation of spores by individual fruit-bodies, (3) that most species of fleshy fungi are in no way protected against slugs, and (4) that very many species of fleshy fungi do not depend upon slugs for the dissemination or germination of their spores.

The Finding of Fungi by Slugs.

Before eating a fungus, a slug must first find it. Now, according to zoologists, the common slugs of English fields and woods, e.g. *Limax maximus* and *Arion ater*, although possessing eyes, can see clearly for a distance of only 1 or 2 mm. and find their food chiefly by their sense of smell*. We must therefore suppose that slugs find the fungi upon which they feed chemotactically, i.e. by changing their direction of locomotion in response to the chemical stimulus arising from the odoriferous substances which the fungi give off.

Previous Chemotactic Experiments.

As evidence that slugs find their food by their sense of smell A. H. Cooke cites the following observations†:

"M. Parenteau was one day walking along a dusty high-road, when he noticed, near the middle of the road, an empty bean-pod and two Arions eating it. Attributing the meeting of feeders and food to mere chance, he was walking on when he noticed a second bean-pod, and, about two yards away from it, a third Arion, hurrying straight towards it. When the Arion had yet

* V. Willem, Arch. Biol. XII, 1892, p. 57, cited from A. H. Cooke, Cambridge Natural History, Molluscs, 1895, p. 185.

† A. H. Cooke, Cambridge Natural History, Molluscs, 1895, pp. 193–194. These observations were first recorded by Moquin-Tandon in his Mollusques de France, I, p. 130.

more than a yard to traverse, M. Parenteau picked up the bean and put it in his pocket. The Arion stopped, raised its head, and turned in every direction, waving its tentacles, but without advancing. M. Parenteau then carried the bean to the other side of the road, and put it in a small hole behind a piece of stone. The Arion, after a moment's indecision, started off straight for the bean. Again the position of the precious morsel was changed, and again the Arion made for it, this time without being further tantalised.

M. Moquin-Tandon noticed, one rainy day in the botanical gardens at Toulouse, two *Limax maximus* approaching a rotten apple from different directions. He changed the position of the apple several times, placing it at a sufficient distance to be sure they could not see it, but they always hit it off correctly, after raising their heads and moving their long tentacles in every direction. It then occurred to him to hold the apple in the air, some centimetres above the head of the Limax. They perceived where it was, raised their heads and lengthened their necks, endeavouring to find some solid body on which to climb to their food."

As confirming M. Moquin-Tandon's experiment, and as further evidence that the olfactory sense in Limaces is extremely acute, J. W. Taylor in his Monograph relates the following*:

"Mr L. E. Adams, about ten o'clock, one dark, windy, and wet evening in August, 1897, at Clifton, Derbyshire, saw a *Limax maximus* crawling directly toward a plate upon the lawn, containing the remains of the dog's dinner; when first observed the slug was about six feet distant from the plate, but within thirty minutes had reached it; the plate was then removed to a second position, about six feet away, but in another direction; the slug almost immediately changed its course, and again made straight towards the plate, on again nearing it the same process was repeated with the same result, the plate being finally removed and placed in a fourth position, eight feet away, and directly to the leeward of the slug, yet in a little more than half-an-hour the slug had reached the plate."

Ernst Stahl† of Jena, whilst carrying out some extended investigations upon the chemical and physical means by which certain plants are protected from the attacks of slugs and snails, incidentally convinced himself by experiment that slugs find their way to their food by their sense of smell. He placed a

* John W. Taylor, Monograph of the Land and Freshwater Mollusca of the British Isles (Testacellidae, Limacidae, Arionidae), Leeds, 1907, p. 37.

† Ernst Stahl, Pflanzen und Schnecken, Eine biologische Studie über die Schutzmittel der Pflanzen gegen Schneckenfrass, Jena, 1888, pp. 15–16, footnote.

slug (Limax) upon a moistened dinner plate and with his mouth blew gently upon it in a horizontal direction. He found that the current of air so produced had no particular effect upon the slug's movements. He then put a cup fungus, *Peziza vesiculosa*, between his mouth and the slug and continued blowing. The slug then immediately changed its behaviour. If the slug's head had been turned away from the experimenter, the slug raised it, moved its tentacles about in the air, soon turned the front part of its body round, and then steered, as the blowing continued, straight toward the fungus. That the slug sought its food by its sense of smell and not by its sense of sight, Stahl showed as follows. He blew over the Peziza as before and waited until the slug had approached to within about 1 cm. of its surface. He then took another Peziza, placed it upon the opposite side of the plate, and blew over it toward the slug. The new current of air was thus made to move in the opposite direction to the first one and to pass over the second fungus, the slug, and the first fungus successively. Stahl then observed several times that the slug, although only 1 cm. away from the first fungus and many cm. away from the second, turned round, left the near-by first fungus, and crawled directly toward the distant second one from which the current of air was coming. It was only when the slug was almost touching the first fungus that Stahl was unsuccessful in trying to induce the slug to turn round and seek the second.

New Chemotactic Experiments.

With a view to testing the supposition that slugs find their food, and in particular find fungi, by their sense of smell, I have made a series of experiments, under conditions as natural as possible, upon the attraction of *Limax maximus* to *Phallus impudicus* and to certain Hymenomycetes. Before giving an account of these experiments, however, it will be necessary for me to make a few preliminary remarks upon both the Limax and the Phallus.

According to Simroth and Scharff, the food of *Limax maximus* consists of non-chlorophyllaceous substances, while anything containing chlorophyll is as a rule refused*; and W. A. Gain considers *Limax maximus* a very dainty feeder, preferring fungi to all other foods†. Stahl‡ divided slugs and snails into *omnivora* and *specialists* and states that *Limax maximus* is a specialist which feeds chiefly on fungi.

Limax maximus, like most other slugs, hides during the day in crevices under stones or in the soil, and only emerges from its

* A. H. Cooke, *loc. cit.* p. 31.
† *Ibid.* p. 32.
‡ E. Stahl, *loc. cit.* p. 15.

place of retreat as darkness is coming on. It was therefore necessary for me to make my experiments during the evening and night. Slugs and snails possess to a considerable degree the power of *homing*, i.e. of returning to the same hiding place day after day, after their night excursions in search of food*. My observations have convinced me that *Limax maximus* is a homing slug. The slugs used in my experiment had a fixed abode to which they always returned after their nocturnal peregrinations; and the realisation of this fact was of considerable help to me in suitably arranging the position of the fungus fruit-bodies which I wished the slugs to visit.

It has been calculated that an average-sized snail of moderate pace progresses at the rate of about a mile in 16 days and 14 hours†. This works out at about 13·3 ft. per hour. The rate of movement of *Limax maximus* is probably not very different from that of a snail. On one occasion I found that a *Limax maximus* had travelled from one point to another 12 ft. distant in 1 hour and 20 minutes; but the course taken was not the shortest possible, so that I have no doubt that the actual pace of the slug somewhat exceeded 10 ft. an hour.

Phallus impudicus—the Stink-horn Fungus—as every botanist is aware, is one of the most remarkable of all fungi. The young fruit-body—sometimes known as a Devil's Egg—is a soft spherical white ball, a little larger than a hen's egg; and it is protected upon its exterior by a thick gelatinous peridium. At maturity, the ball suddenly bursts at the top, and then there emerges from it in the course of about half-an-hour a sort of Jack-in-the-Box made up of a long, white, hollow, spongy, bread-like stipe bearing at its free end a conical cap covered with dark green slime. The slime contains sugar and millions of green spores, and from it issues a very powerful and offensive odour. Dung flies are attracted to the fungus by the smell, alight upon the green cap, lick up the sweet slime, and carry away the spores upon their straggling legs and inquisitive proboscides and within their alimentary canals. Thus the spores of the fungi are disseminated through the agency of insects.

The smell from the cap of an expanded *Phallus impudicus* attracts not only flies during the day but also slugs during the night. Early in the morning I have several times found an expanded fruit-body with a stipe which had been half-eaten by slugs during the previous night, the slime left upon the fungus and the nature of the damage affording a clear indication of the identity of the marauders; and, in the twilight of the evening, I have sometimes found a slug, *Limax maximus*, actually upon a Phallus engaged in feeding.

* A. H. Cooke, *loc. cit.* pp. 34–36. † *Ibid.* p. 46.

Experiment I. At my father's house at Birmingham, England, there is a smooth, well-compressed, gravel carriage-way which is oval in form, 40 ft. wide and 60 ft. long. On a border, at the edge of the gravelled area, one evening in August as darkness was setting in, I found an expanded Phallus upon which a slug, *Limax maximus*, was feeding. I removed the slug and set the fungus upon the gravel at a distance of 10 ft. from the edge of the border. The next morning I found that a slug had visited the fungus upon the gravel, and the slime-track revealed that the slug had come from the border where I had first found the fungus with a slug feeding upon it. The track was very direct from the border to the fungus. It therefore appeared that the Phallus had attracted the slug chemotactically for a distance of at least 10 ft.

Experiment II. Shortly after making the above experiment, on August 28, 1920, I visited Sutton Park, Warwickshire, and there procured nine large Phallus balls from under a Holly bush. The balls were full-grown, but still quite odourless; and their stipes were beginning to elongate, for I could feel them in some of the balls pressing upwards against the top of the peridium. I took the balls home to my father's garden, planted them in damp soil in pots, and set the pots in the greenhouse. Two days afterwards, one of the balls opened and a tall stipe covered with a strongly odorous dark-green cap emerged. In the evening I set the expanded Phallus in the middle of the gravelled area. Next morning I found that the fungus had been visited by a slug which, as indicated by its slime-track, had crept over the gravel for a distance of about 21 ft.

Experiment III. The other Phallus fruit-bodies opened one by one, and with them I made several other experiments like the one just described. In one of them a slug came at night about 24 ft. over the gravel to two fruit-bodies which were in one pot, ate a piece out of each of the two stipes, and then crept between the bottom of the pot and the gravel. When I raised the pot in the morning, in order to take it to a place where the Bluebottle flies could not eat up all the green slime, I found the slug beneath. The slug was kindly identified for me by Mr P. T. Deakin as *Limax maximus* var. *obscura*.

On three other nights I placed pots with expanded Phallus fruit-bodies in the middle of the gravelled area, but no slugs visited them. This may have been due in part to the paucity of slugs in the borders and in part to the weather being rainy and windy. The successful experiments were performed on still nights. Slime tracks were only found in the morning upon the gravel when a slug had visited a Phallus during the previous night.

The above observations show that *Limax maximus*, under natural conditions, guided by its sense of smell, sometimes travels from 21 to 24 ft. toward an expanded fruit-body of *Phallus impudicus* and that, upon coming in contact with the fruit-body, it feeds upon the stipe.

I employed *Phallus impudicus* for my first experiments upon the chemotaxis of slugs because of its very powerful odour and the convenience with which I could procure and handle its fruit-bodies; but I have found that similar experiments can be performed with Boleti and Agaricineae.

Experiment IV. On September 8, I procured three fresh fruit-bodies of *Boletus scaber* from a wood and, in the evening of September 9, placed them upon the gravelled area at a distance of 10 ft. from the border. During the night a slug came from the border across the gravel to the fruit-bodies and ate three holes in the top of one of the pilei. A similar experiment made at the same time with a large fruit-body of *Russula heterophylla* was also successful.

Experiment V. The next evening, September 10, about 8 p.m., I placed upon the gravel three little heaps of hymenomycetous fruit-bodies. In the first heap were the three fruit-bodies of *Boletus scaber* which had been used the night before, in the second three fruit-bodies of *Cortinarius caninus*, and in the third three fruit-bodies of *Russula nigricans*. Each heap was made at a distance of 12 ft. from the border and the three heaps were in a row, the central heap being that of *Boletus scaber* and the intervals between the heaps being 4 ft. Having had considerable difficulty in some of the previous experiments in tracking the slime-trail upon the gravel owing to the intermittency or thinness of the trail and owing to the effects of dew, I placed some large fern leaves in a line along the edge of the gravel by the border, so that, if a slug crossed the line, it would leave a trail behind which could be easily detected. The night was a very dark one. About 10 p.m. I went out with a lighted taper to see what was happening. On examining the fern leaves I found upon the leaflets a shinging slime-trail, the direction of which proved that the fern line had already been crossed by a slug. I then hunted about on the gravel and found the slug, a *Limax maximus*, about 4 inches long, actually on its way to the fungi. The slug was already 4 ft. from the border whence it had come and was heading in the right direction to reach the row of fungus heaps some 8 ft. distant. I noticed, however, that the path of approach to the fungi was by no means a straight line but was made up of a series of curves. At 10.45 p.m. I found the slug about 4 ft. from two of the heaps of fungi, and at 11.20 p.m. I found the slug actually upon one of the fruit-

bodies of *Boletus scaber* quietly feeding. No other slug could be seen anywhere. The next morning I detected the slime-trail of the slug in the neighbourhood of the heap of Boleti but nowhere else, the trail having been weakened or destroyed by dew formation; and the slug had disappeared. In all probability the slug had returned to the border whence it had originally come.

Experiment VI. The next evening, September 11, I set out upon the gravel the same three heaps of fruit-bodies as had been used the night before. Again the heaps were made in a row parallel to the edge of the border, the intervals between the heaps being 4 ft., the *Boletus scaber* heap occupying the central position in the row and the *Cortinarius caninus* and *Russula nigricans* heaps the end positions. However, the arrangement of the heaps differed from that of the night before in that each heap instead of being only 12 ft. from the edge of the border was now 20 ft. The condition of the *Russula nigricans* and *Cortinarius caninus* fruit-bodies was still good, but the *Boletus scaber* fruit-bodies were now in an advanced stage of putrescence. The evil state of the *Boletus scaber* fruit-bodies was perhaps the reason why, as we shall see in the sequel, they were not visited by a slug in this particular experiment. The night was again very dark and still. At 9.40 p.m., with the help of a lighted taper, I found a *Limax maximus* which had just emerged from its hiding place and which was moving behind a block of sandstone in the border 21 ft. from the fungi. At 11 p.m. I went out again and found that the slug had already travelled 11 ft. upon the gravel toward the fungi from which it was now only 9 ft. distant. I watched the slug for a little time but, being afraid of disturbing it too much, soon retired into the house. At 12 p.m. I sought the slug again and found it 6·5 ft. away from the row of fungi; but, to my surprise, it was moving away from the row of fungi instead of toward it. At 1 a.m., the slug was 5 ft. away from each of the heaps of *Boletus scaber* and of *Russula nigricans*; at 1.30 a.m., about 2 ft. away; and, finally, at 2 a.m., actually upon one of the fruit-bodies of *Russula nigricans* devouring the gills. Thus the slug, after some five hours of wandering, had at last succeeded in finding one of the heaps of fungi set 20 ft. from the edge of the border where the slug had first been seen.

The slug, between 9.40 p.m. and 11 p.m., must have travelled almost directly toward the fungi; for, during this period, it traversed 1 ft. of border and 11 ft. of gravel in the direct line of its journey. But between 11 p.m. and 1 a.m. this rapid progress was not kept up and there was a great waste of time, for during this period the net advance of the slug toward the fungi

was only 4 ft. The slug, as the track showed the next morning, seems, during these two hours, to have wandered more or less round and round in a knotted manner as if it had had some difficulty in detecting the scent of the fungi. As it happened, the slug was obliged to cross the line where the heaps of fungi had lain during the previous night and day, and it is therefore possible that the fungi had in some way scented the ground and that the scent had mis-led the slug. It is also possible that variations in air currents took place in such a way as to send the odour of the fungi in the heaps toward the slug only very intermittently. But, whatever may be the true explanation, it is certain that between 11 p.m. and 1 a.m. the slug lost much time and spent a considerable amount of energy in fruitless wandering.

There was nothing upon the gravel for the slug to eat except the fungi I had placed there and, if the slug had continued in the direction in which it set out without finding the fungi, it would have traversed a gravel desert 60 ft. across.

At 2 a.m., as soon as I had found the slug which had been under observation, upon a *Russula nigricans* fruit-body, I hunted carefully over the gravelled area for other slugs. I could find one more slug only—another *Limax maximus*—which had come out of the border and was heading straight for the row of fruit-body heaps from which it was only 8 ft. distant; but whether or not this second slug ever reached one of the heaps I cannot say, as at 2.5 a.m. I retired to bed and, in the morning, could not clearly distinguish the trail.

In the morning of September 12, I found that the slug which had visited the *Russula nigricans* fruit-bodies was no longer to be seen upon the gravel. Doubtless, it had once more retired to the border. It is doubtful whether the return journey could have been accomplished in less than two hours. It appears, therefore, that our *Limax maximus*, with the object of feeding upon a fungus and then returning home, must have spent some six or seven hours in a single night in wandering over the gravel where the fungus was. Such an effort shows how strongly fungi attract slugs of the *Limax maximus* species. Doubtless, the slugs in woods are also attracted to fungi from a distance of many feet. In view of my observations on *Limax maximus*, the success with which slugs in woods find out the fleshy Hymenomycetes can no longer be a matter for astonishment.

Experiment VII. On September 12, I made a fourth experiment with hymenomycetous fruit-bodies. On this occasion I used the *Russula nigricans* and *Cortinarius caninus* heaps alone, as the *Boletus scaber* fruit-bodies had now become thoroughly

decomposed. I set the two heaps of fruit-bodies on the gravel 4 ft. apart and each 21 ft. distant from the place in the border from which the slugs usually issued on their nocturnal forays; but the new position of the fungi was such that the slugs, if they sought the fungi, would be obliged to travel not in the direction taken during the previous two nights but in a direction making therewith an angle of 45°. The night was very still, and dark; there was no moon, and overhanging trees shut out from that part of the gravel which the slugs would be obliged to cross even the faint light of the stars. At 11.30 p.m., with the help of a taper, I found a slug moving toward the two heaps of fungi and only 9 ft. distant from them. It was a *Limax maximus*, exactly resembling the two I had seen the previous night, and its four horns were spread out in the air as though they were being used to detect the direction from which the odour of the fungi was coming. I could see by the slime-trail upon fallen leaves and gravel stones that the slug was making a gentle sweep toward the *Russula nigricans* fruit-bodies and that it had kept upon a steady course since it had left the border. Next morning, I found that the *Russula nigricans* fruit-bodies had been visited by two slugs during the night, for there were four slime-tracks passing between them and the border. Moreover, one large cavity and two smaller ones had been made by the slugs in one of the pilei. By careful tracking, I found that one of the slugs which we will assume was homeward bound, after feeding upon one of the *Russula nigricans* fruit-bodies, had made a détour and had visited the heap of *Cortinarius caninus* fruit-bodies. Here it had crept on to one of the pilei and tasted the gills, and then it had retired by a somewhat sinuous course to the border from which it had set out, 21 ft. away. The actual distance traversed by this slug in the course of its excursion to the two heaps of fungi must have been at least 50 ft.

The circumference of a circle with a radius of 21 ft. is 132 ft. The width of my heap of *Russula nigricans* fruit-bodies was 4 inches. Supposing, therefore, that the heap of fruit-bodies were on the circumference of a circle with a radius of 21 ft., as was actually the case in the experiment just recorded, and supposing, further, that a slug were to start from the centre of this circle and move at random radially outwards for a distance of 21 ft., the chances of the slug meeting the heap of fruit-bodies would be 395 to 1 against. Simple mathematical calculations of this kind afford strong evidence that the slugs in my experiments did not find the fungi in the night by chance but through the guidance of some stimulus coming from the fungi and received by their sense organs.

Immediately after making Experiment VII, I was obliged to leave England to return to my duties in Canada. My investigations upon the finding of fungi by slugs were thereby brought to an end.

Slugs and Mustard Gas.

There can be but little doubt that the stimulus which comes from the fungi to the slugs and which guides these animals on their foraging expeditions is gaseous in nature. It has been recently shown by Dr Paul Bartsch of the Smithsonian Institute, Washington, that *Limax maximus* is extraordinarily sensitive to certain gases. A few years ago a number of slugs of this species, which were under observation in his home, escaped from the box in which they had been confined. Their behaviour in the furnace room showed that they were sensitive to the fumes coming from the furnace and, in response thereto, made characteristic movements of their tentacles. After the United States entered the War and the need for a gas detector arose in connection with the fighting at the front, Dr Bartsch recalled his furnace-room observations. A very brief period of experimentation then revealed the extraordinary sensitiveness of *Limax maximus* to mustard gas, and such startling results were obtained that within two hours after the first experiment had been made, the Allied forces were advised by cable of the possibilities of using the slug as a gas detector. Dr Bartsch found that the tentacles of *Limax maximus* are sensitive to a dilution of 1 in 10,000,000 of mustard gas, and that they make characteristic responses indicating the degree of dilution. Dr Bartsch also found that man reacts to a dilution of 1 in 4,000,000. *Limax maximus*, therefore, is much more sensitive to the presence of mustard gas than man*. If *Limax maximus* is thus so extraordinarily sensitive to one gas, we have every reason for believing that it is extraordinarily sensitive to other gases, particularly those which emanate from its food substances such as fungi. If we assume such a sensitiveness, it is not difficult to imagine how it is that *Limax maximus* finds its way unerringly over a distance of many feet to the fruit-bodies of Phallus, Boletus, Russula, etc., which it devours with such avidity. The sense of smell in slugs, like that in dogs, is doubtless much more acute than in human beings.

* Paul Bartsch, Our Poison Gas Detector and How It was Discovered, Abstract of an Address delivered on Feb. 7, 1920, to the Biological Society of Washington, U.S.A. I read a paper entitled "Upon the Chemotactic Attraction of Fungi for Slugs" at Chicago on Dec. 30, 1920, before the Ecological Society of America. Subsequently Dr R. F. Griggs called my attention to Dr Bartsch's work, and then Dr Bartsch kindly sent me an abstract of his Address.

Conclusions.

(1) The successful experiments with *Phallus impudicus*, *Russula heterophylla* and *R. nigricans*, described above, clearly show that the fruit-bodies of these fungi, under certain conditions in the open, attract *Limax maximus* from a distance of at least 10 to 21 ft.

(2) Having regard to the well-known short-sightedness of slugs, to the fact that slugs find their food at night, and to the sensitiveness of *Limax maximus* to mustard gas when diluted to one part in ten million, my observations and experiments lead me to suppose that fungus-eating slugs react at a distance to the odours given off by fleshy fungi, and that in woods and gardens they find the fungi upon which they feed by their sense of smell.

(3) The chemotaxis of slugs, not merely for fungi but also for garden produce such as lettuce and cabbage, is a subject concerning which our information is still very meagre, but which is very amenable to experimental treatment. If the chemotaxis of slugs were sufficiently elucidated, we might perhaps be able to devise much more efficient means for protecting our gardens from the ravages of slugs than any at present known.

ON THE SYMPTOMS OF WILTING OF MICHAELMAS DAISIES PRODUCED BY A TOXIN SECRETED BY A CEPHALOSPORIUM.

By W. J. Dowson, M.A., F.L.S., Royal Horticultural Society's Garden, Wisley, Ripley, Surrey.

The investigation of a serious and widespread wilt disease of Michaelmas Daisies undertaken at Wisley in the autumn of 1920 and not yet completed has already led to definite results concerning the action of the parasitic fungus involved.

In the present paper it is intended to give only an account of the experiments which led to the conclusion that the symptoms of the disease are due to the secretion of a toxic substance by the parasite. The complete account of the investigation of the disease including the morphology of the parasite is left over for a further paper. In recent literature dealing with wilt diseases due to species of *Fusarium* investigators have suspected that the actual symptoms of wilt are due, not so much to the clogging of the vessels and tracheids of the xylem thereby causing an

interference with the conduction of water, but rather to the action of some toxic substance secreted by the mycelium and taken up in the transpiration current.

Thus, Johnson (1) writing on the Fusarium wilt of tobacco says "nevertheless, from the behaviour of the diseased plants, especially with regard to yellowing and early turgidity, it is not believed that death of the plants is due to clogging of the vessels but rather to toxic materials formed by the parasite, or as a result of parasitic action on the host." Cromwell (2) investigating the Fusarium blight of the Soy bean says, "it seems, therefore, that the symptoms produced result not simply from a mechanical clogging," and he goes on, "a reduction of the activity of the protoplasm due to the possible presence of toxins secreted by the fungus...."

Little work has yet been done on the actual isolation of such a substance. Hutchinson (3) showed in the case of *Bacillus solanacearum* that the toxin secreted by the bacilli in pure culture could be filtered off and when introduced into a living tobacco plant would produce the symptoms of the disease. Quite recently Young and Bennett (4) working with a Fusarium isolated the lethal principle by precipitation with alcohol, redissolved it in water and showed that the solution still possessed its poisonous properties. Professor V. H. Blackman has informed me that similar results have been obtained at the Imperial College of Science, but these have not been published.

The Michaelmas Daisy disease is due to a parasitic fungus which for the present is regarded as a species of Cephalosporium, as only its conidial stage has been ascertained. The fungus has the property of growing in a watery medium in the form of a slimy sheet of mycelium with the copious production of minute conidia.

The cultures were made in 500 cc. flasks containing in one series 200–300 cc. of sterilised water (distilled) and some flamed pieces of diseased Aster stems, long enough to rest against the sides of the flask above the surface of the liquid, and in another series 200–300 cc. of distilled water together with similar pieces of healthy Aster stems. The flasks of the second series were steamed for three hours and when cool were inoculated with mycelium from an agar plate culture. In both series the Cephalosporium mycelium grew downwards on to the surface of the liquid and in four weeks became visible as a thin slimy sheet, the liquid also had become brown in colour and resembled tea in appearance. After being drawn through a Berkfeld filter by a water pump, the liquid thus freed from conidia, and therefore sterile, was poured into a series of small sterilised glass bottles. Another series of similar glass bottles

was filled with boiled tap water, and into both were inserted vigorous green shoots of Michaelmas Daisies. The mouth of each bottle was lightly plugged with cotton wool to keep out dust and to lessen evaporation. All the bottles with their shoots were placed side by side close up to a window. After three days some of the leaves of the shoots in the filtered culture fluid became mottled with paler patches which soon spread and involved the whole surface of the leaves. More leaves became mottled and paler, until on the seventh day nearly all the leaves were bright yellow, shrivelled and dry. The stem which bore them also turned yellow.

(These symptoms of mottling, paling, and yellowing were also observed in inoculation experiments with Cephalosporium.)

The controls in water remained green and turgid until the tenth day when loss of turgor and shrivelling commenced, but no yellowing.

In another series of experiments the filtered fluid was placed in a dialyser of gold-beater's skin suspended in a small beaker of boiled tap water. After three days the water in the beaker outside the dialyser became slightly brown in colour and into this were inserted, as before, green healthy shoots of Michaelmas Daisies. Controls in which the filtered culture fluid was replaced by boiled tap water in the dialyser were also set up. The shoots in these remained as before quite green and turgid for ten days, but those in the dialysed liquid presented mottled leaves after two to three days and at the end of six nearly all were bright yellow and shrivelled.

The effect was more marked and more rapid with the filtered and dialysed liquid. In one of the experiments with the filtered and dialysed liquid, green shoots of the resistant variety "Gladys Donellan" were used to see if this plant behaved towards the toxic substance in a different way than did the susceptible varieties.

The shoot was affected in the same way and in the same time as any other variety tried, thus indicating that "Gladys Donellan" is resistant to the fungus but not to the toxin. Eventually as this experiment and inoculations showed "Gladys Donellan" succumbs as do other varieties of Novae Belgii and Novae Anglii, but takes longer over the process. Or, to put it in another way the mycelium cannot grow so quickly in the wood of "Gladys Donellan" as in other varieties, and therefore produces less toxin in a given time.

The symptoms of wilting noted in the above experiments were repeated almost exactly when Michaelmas Daisy plants were inoculated with the mycelium of the fungus. The rapidity with which the effect was produced indicated the crystalloid

nature of the toxic substance, a supposition which was completely demonstrated by the second series of experiments when the dialyser was employed.

In a third set of experiments hanging drops of the filtered liquid were used, into which were stirred some mesophyll cells obtained by gently scraping the upper surface of a Michaelmas Daisy leaf with a flamed scalpel in a little distilled water. In this way it was possible to watch the effect of bringing the assimilating cells of the host into direct contact with the toxic substance produced by the parasite. After twenty-four hours it was noticed that the chloroplasts of certain cells had altered in position. Instead of lining the longer walls of the palisade cells, they were more numerous towards one or both ends of such cells, so that a gap devoid of chloroplasts appeared either at one end or at the centre. The migration of the chloroplasts went on until at the end of three to four days they were massed together at one or both ends of the cells, but were still quite distinguishable one from another. During the next few days the chloroplasts slowly lost their shape and colour; and by the end of the sixth or seventh day had become an irregularly shaped bright yellow mass. At about this time the cells commenced to plasmolyse indicating the death of the protoplast.

Thus it would appear from these observations together with those on inoculated plants, and on the cut shoots placed in the filtered culture liquid, that the first outward signs of disturbance —the mottling—is due to the action of a toxin on the assimilating tissue, and corresponds with the migration of the chloroplasts, whereby a space devoid of these bodies is left in a large number of cells. The final bright yellow appearance of the leaves, so typical of wilt diseases, is due to the yellow fused-up mass of chloroplasts at the ends of the palisade cells.

REFERENCES.

(1) Johnson, J. Fusarium Wilt of Tobacco. Journ. Agric. Res. xx, No. 7, 1921, p. 519.

(2) Cromwell, R. O. Fusarium Blight of the Soy Bean and the Relation of Various Factors to Infection. Agric. Exp. Sta. Nebraska. Bull. 14, 1919, p. 14.

(3) Hutchinson, C. M. Rangpur Tobacco Wilt. Mem. Dept. Agric. India, 1913, I, No. 2.

(4) Young, H. C. and Bennett, C. W. Studies in Parasitism in the Fusarium Group. Abs. in Phytopathology, xi. 1921, p. 56.

OBSERVATIONS ON A DISCOMYCETE FOUND ON MEDLAR FRUITS.

By H. Wormald, D.Sc., Research Department, South-Eastern Agricultural College, Wye, Kent.

In 1920 the present writer* recorded the occurrence in this country of a fungus found associated with, and apparently the cause of, a leaf blotch of Medlar trees (*Mespilus germanica* L.). The fungus appeared on the upper surface of the diseased leaves in the form of grey tufts which were often confluent in lines along the principal veins and consisted of chains of almost spherical conidia; these conidia were connected by the slender fusoid bodies known as "disjunctors."

On comparing this fungus with the description and figures given by Schellenberg† it was evident that it was the conidial stage of *Sclerotinia Mespili*. That author found the apothecial stage of the fungus on the mummied Medlar fruits. He stated that these mummies were the result of infection brought about by the transference, by insects, of conidia from diseased leaves to the flowers.

During the latter half of April and the first fortnight of May, 1920, specimens of the leaf blotch were sent to Wye College from five localities, four in Kent, the other in Somersetshire. At two of these a search was made under affected trees for the apothecial form of the fungus. On the trees and also on the ground beneath them were found small dried up undeveloped Medlar fruits but in no case could apothecia be discovered on these. Some of these mummies were collected towards the end of April (1920) and brought to the College where they were placed on the surface of ordinary garden soil in two plant pots; in one pot were placed those collected from the ground, in the other those taken from the tree. The pots were then left exposed in the open.

A microscopic examination of a number of these mummies showed the presence of hyphae in the tissues, and almost invariably numerous, minute, spherical, spore-like bodies (microconidia or sporidia) could be obtained by placing scrapings from the surface of the fruits in water. Cultures were obtained from

* Wormald, H., On the Occurrence in Britain of the Conidial Stage of *Sclerotinia Mespili* Schell., Ann. Appl. Biol. VII, Nos. 2 and 3, pp. 173–6, Dec. 1920.

† Schellenberg, H. C., Ueber *Sclerotinia Mespili* und *Sclerotinia Ariae*, Cent. für Bakt. Abt. 2, Bd. XVII, pp. 188–202, 1907.

the internal mycelium and these resembled in their mode of growth others obtained from conidia taken from the leaves. In such cultures micro-conidia similar to those obtained from the surface of the mummies were invariably produced. No macro-conidia, i.e. similar to those which develop on the leaves, were formed in any of the cultures.

When the pots were examined about the middle of the following February (1921) it was seen that on some of the mummies in the pot containing those collected from the ground, there were present rounded villose brownish outgrowths, 1 to 1·5 mm. in diameter; by March 1 these outgrowths had become more or less conical, being broadest near the base and tapering to a bluntly pointed apex. On March 14 it was noticed that these outgrowths were being devoured by slugs so some of the mummies were brought into the laboratory and placed on moist filter paper in a large Petri dish. Under these conditions development continued and by March 21, the upper portion of each outgrowth had elongated to form a stalk with a slightly swollen terminal knob which in some cases was already provided with a central pore. The pores gradually increased in size, the fructifications becoming cup- or funnel-shaped, and by March 29 well-developed apothecia were present on two of the mummies, which bore ten and twelve sporophores respectively. Three days later the apothecia had become almost plane and were splitting at the margin. As the apothecia reached maturity it was found that, on removing the lid of the dish containing them, the spores were discharged in little visible clouds. Later several such discharges were distinctly seen on placing a mummy bearing ripe apothecia on black velvet exposed to sunlight.

The number of sporophores growing from a mummy was variable; of those left in the open very few attained to their full development owing to the depredations of the slugs, but observations showed that the early stages (the rounded villose outgrowths referred to above) of some ten or more sporophores usually appeared on each mummied fruit. On one of the specimens brought indoors fifteen sporophores were counted.

It is to be noted that the mummies were collected in the spring of 1920 before the trees came into flower; they had therefore passed the previous winter either on the tree or on the ground and, when the apothecia appeared, had been exposed in the open during two (at least) winters. That the medlar fruits do not produce apothecia until the second year after infection was observed by Schellenberg*; the same period is also required by other species of Sclerotinia, as shown by

* *Loc. cit.* p. 189.

Fig. 1. Asci, showing the change which takes place preparatory to the discharge of the spores × 500. *a* and *b*, not vacuolate. *c* and *d*, several vacuoles present. *e* and *f*, one large vacuole in each extending almost to the base.

Aderhold and Ruhland* for *S. fructigena* and the form they refer to *S. laxa*, and by the present author† for *S. cinerea*.

* Aderhold, R., u. Ruhland, W. Zur Kenntnis der Obstbaum-Sklerotinien. Arb. Biol. Abt., Land-u.-Forst. Kaiserl. Gesundheitsamte, IV, pp. 427–42, 1905.

† Wormald, H. On the Occurrence in Britain of the Ascigerous Stage of a "Brown Rot" Fungus. Ann. Bot. XXXV, pp. 125–135, 1921.

From the fructifications examined the following general description was obtained:

The stipe was from 2 to 5 mm. long, pale brown in colour; the receptacle was 3 to 9 mm. in diameter when fully expanded, at length plane or even slightly convex and lobed by the splitting of the margin, pale brown at the edge but darker towards the centre.

On teasing out the hymenium the asci could be found in various stages of development. In some the ascospores were not defined while in those in which the spores were fully formed three stages could be distinguished, viz. (1) asci in which the eight spores extended from the apex to half-way or more down the ascus, the spores being surrounded by protoplasm which extended without vacuoles to the base of the ascus, (2) those in which several vacuoles were present while the spores were pushed nearer the apex so that they extended barely to the middle of the ascus, (3) asci with a single large vacuole extending from the apex almost to the base, the spores being in the upper one-third (or very little more) of the ascus (Text-fig. 1).

The more mature asci, i.e. those in which there was a single large vacuole were on the whole longer and broader than those described under (1) and (2). Thus of those asci which were not vacuolate or which contained several comparatively small vacuoles the dimensions were 144–171 × 7·5–9 μ, while those in which a single large vacuole extended almost the whole length of the ascus were found to measure 159–210 × 9·5–12 μ.

The ascospores were variable in shape and size; they were generally ovoid to ellipsoid but often rather irregular, thus they were sometimes flattened on one side, some were pyriform, others were elongate becoming more or less fusiform and sometimes almost pointed (Text-fig. 2). In size they showed a range of from 10 to 19·5 μ in length and 5 to 7·5 μ in width; the great majority however came within the limits 12–16 × 6–7 μ. The average of 100 spores was found to be 13·6 × 6·4 μ. As showing the variation in size and relative proportions the following may be given as examples: 19·5 × 6·5 μ, 10 × 7·5 μ, 10 × 6 μ, 15·5 × 5 μ, 13 × 7 μ. No definite guttules were observed.

The apical pore of the ascus stained blue with iodine. The paraphyses were about the same length as the asci, usually swollen at the apex and unbranched or occasionally with one branch.

One of the few sporophores which reached maturity in the open was found fully expanded on April 8 and was examined microscopically; the asci and ascospores resembled in shape and size those previously examined. It is to be assumed therefore that the morphology of the fungus was not appreciably modified

by bringing the mummies indoors, although the later stages of development, leading to the discharge of the spores, were accelerated.

The foregoing account of the form examined at Wye differs but slightly from that given by Schellenberg for the ascigerous stage of *Sclerotinia Mespili*, if allowance is made for a smaller range of variation in the various morphological characters as recorded by him; the chief discrepancy is in respect to the width of the ascospores. It may be of interest to summarize

Fig. 2. Ascospore, showing range of variation in shape and size. ×650.

the above description in tabular form side by side with that of *S. Mespili*.

Schellenberg's description of *S. Mespili* summarized	The Medlar Sclerotinia described in this paper
The apothecia borne by each mummied fruit were few in number (mostly 1 or 2, but two fruits each bore 3 apothecia, and one had 4).	Apothecia more numerous, 8 to 15 on each fruit except in those cases where most had been eaten by slugs.
Stalk of apothecium 3–5 mm. in length (as shown by his figures).	Stalks 2–5 mm.

Schellenberg's description of *S. Mespili* summarized	The Medlar Sclerotinia described in this paper
Diam. of cup 6–8 mm.	Diam. of cup 3–9 mm.
Apothecium bell-shaped to cup-shaped without recurved margin; margin becomes split irregularly.	Apothecium funnel-shaped to cup- or saucer-shaped, at length plane or even slightly convex, and lobed by the splitting of the margin.
Asci 160–180 × 8–12 μ (3 asci are figured all with several vacuoles); apical pore stained blue with iodine.	Asci: (*a*) with no vacuoles or several small ones 144–171 × 7·5–9·0 μ. (*b*) with one large vacuole 159–210 × 9·5–12 μ; apical pore stained blue with iodine.
Paraphyses as long as asci, slightly swollen at apex (figured as simple or with one branch).	Paraphyses about as long as asci, unbranched or with one branch, usually swollen at tip.
Ascospores ellipsoid to ovoid often with a point at each pole, 12–15 × 9–11 μ	Ascospores rather irregular, usually ellipsoid to ovoid, but often pyriform or fusiform, sometimes almost pointed, 10–19·5 × 5–7·5 μ, mostly 12–16 × 6–7 μ. Average size 13·6 × 6·4 μ.

The mode of development of the ascophore from the mummified fruit is described by Schellenberg as follows: "Wenn aus dem Sclerotium sich ein Apothecium bildet, so tritt die Ablage [? Anlage] als kleiner fleischiger Höcker aus der Frucht heraus. Diese wird gestielt und das knopfförmige Ende breitet sich nach und nach zur Glockenform aus*." This is not in accordance with my own observations, for when the fruits were brought indoors they were under daily observation and it was found that, instead of the primary protuberance becoming stalked and raised up to form the cup, it elongated at its apex; it was thus attenuated upwards and at that stage was more or less conical or flask-shaped so that there was some doubt as to whether it was really a Sclerotinia or whether it was a Sordaria, a genus characterized by a flask-shaped perithecium. No pore appeared however until there was further apical elongation and the development of a terminal head which finally expanded to form the cup.

Schellenberg describes and figures the infection of Medlar leaves with the ascospores. Attempts to induce germination of the ascospores of the Wye specimens failed both in water and on agar plates. Ascospores isolated on the surface of prune juice agar gradually disintegrated without even the protrusion of germ tubes. That fully matured spores behaved thus was shown by catching, on the agar, spores actually shot out from the asci; these could be seen under the microscope in groups of eight and were kept under observation for a week or more, but no germ tubes were developed. Apothecia were then attached

* *Loc. cit.* p. 190.

to twigs of a Medlar tree in the College grounds but no infection of the leaves occurred.

The direct connection between this discomycete and the Monilia with disjunctors found on the leaves was therefore not traced, although the fact, noted above, that a fungus, showing the same habit when grown in plate cultures as that isolated from the leaves, was isolated from the mummies, is suggestive that the two forms are stages in the life cycle of the same fungus. It appears probable therefore that the discomycete is the *Sclerotinia Mespili* of Schellenberg.

SUMMARY.

Mummied Medlar fruits collected from the ground in spring and placed on soil in a pot in the open gave rise to fructifications of a discomycete in the following spring.

The fungus differs but slightly from *Sclerotinia Mespili* as described by Schellenberg.

The differences noticed are:

(1) the ascospores are distinctly narrower;

(2) the stalk of the apothecium develops from the apex of the primary protuberance, not from the base as mentioned by Schellenberg.

STUDIES IN DISCOMYCETES. III.

By Jessie S. Bayliss Elliott, D.Sc. Birm., B.Sc. Lond.

Arachnopeziza aurata Fckl. This fungus has been growing on the under side of a log of wood in my garden during the last five years. In all months of the year I have been able to gather material, but growth is most flourishing during the months June to October. The specimens of the fungus I have gathered hardly justified the specific name *aurata* until this summer, for they have always been nearly colourless, as were also specimens I gathered at Porlock Easter and September 1920. Very marked characters—the fascicle of elongated ascospores, the much-branched paraphyses and the white subiculum—leave no doubt as to the identity of the species under consideration. No doubt the deeper colour of the apothecia gathered in July may be correlated with the brilliant summer weather, the log having received more light in its rather shady quarters this year (1921).

Owing to the presence of a subiculum it was possible to make out the early stages in the development of the apothecia which to some extent agree with similar stages figured for *Eremascus albus* Eidam.

The first indications are seen in the coiling of a short hyphal branch which is extremely delicate and fragile arising from one of the horizontal hyphae of the subiculum round another short delicate vertical hypha of the subiculum, and the gradual convergence of the tips until one touches the other: whether there is actual fusion or not could not be made out: at this stage of apparent fusion the tips of the hyphae become swollen and these portions in material which had been fixed in formalin and stained with haematoxylin coloured more deeply. There

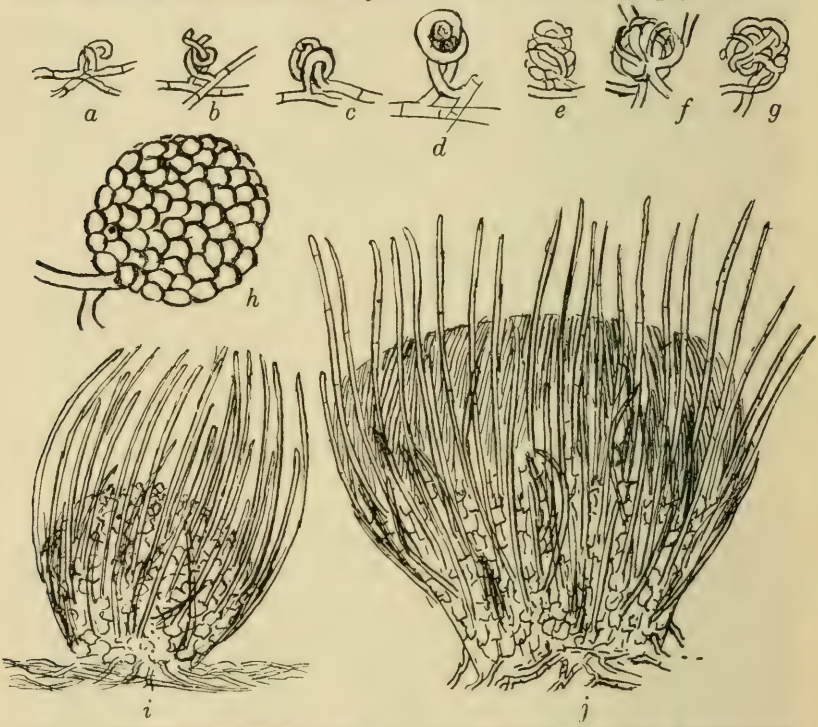


Fig. 1. *Arachnopeziza aurata* Fckl. *a*—*j*, successive stages in the development of an apothecium; *a*—*h*, × 800; *i* and *j*, × 400.

is evidently here a primitive type of sexuality—a fusion of similar gametes—such as is figured for *Penicillium crustaceum* and *Eremascus albus*. Sterile hyphae now cluster round and enclose these fertile hyphae arising from their basal portion, with the result that a ball-like colourless perithecial structure appears: this increases in size and soon possesses a pseudo-parenchymatous exterior. Now various cells from this parenchyma grow out into long hairs which at first converge round the summit of the ball-like structure; these then diverge and

form the marginal hairs and those of the encipulum: they are succeeded at the summit by a much denser growth of very fine converging hairs which later stand erect and are the paraphyses of the now fully exposed though still very miniature hymenium of the apothecium: at this stage a very few asci are developed but none contain ascospores.

Although on staining, nuclei were to be seen in the primordial hyphae and in the asci, they were far too small for any attempt at working out details of cytological structure to be made.

Dasyscypha diplocarpa Curr. During the mycological foray, Sept. 1920 at Minehead, Dr W. T. Elliott found in the Horner Woods an interesting and very rare Discomycete—*Dasyscypha diplocarpa* Curr. The type specimen was found by Currey at Dartford and apparently there is no other record* of the fungus having been found since that time—fifty-seven years ago. Currey described it under the name of *Peziza diplocarpa* in Linn. Trans. XXIV, p. 153, 1864, giving a coloured illustration of the apothecium and also figures of the paraphyses and spores.

The paraphyses are particularly striking in that each is surmounted by a very large elongated oval septate conidium of a pale green colour: it is these coloured conidia which give the beautiful olive green colour to the disc. Currey in his description, copied by Phillips and Massee, has omitted to mention this and also that the paraphyses are very much branched.

Fig. 2. Branched paraphysis of *D. diplocarpa*.

Phillips mentions that "besides the peculiar bodies Mr Currey regarded as paraphyses he found in the original material slender filiform paraphyses": the latter are to be seen in great numbers but they are merely paraphyses from which the top-heavy conidia have fallen off; this readily happens in mounting portions of the hymenium for microscopical examination, for the conidia are very large (20–50 × 5–6 μ) compared with the extremely filiform lower portion of the branched paraphyses to which they are attached.

The ascospores measure 6–7·5 × 3 μ and this agrees with the original measurement given by Currey (7 μ): Massee gives the spore measurement 10–12 × 3 μ and also states that though the spores are for a long time continuous and two guttulate they

* It was recorded from Caughley Wood, Shropshire, at the Worcester Spring Foray, on the 27th May, 1912, see Trans. Brit. Myc. IV, 14. The spores in this gathering measured 7–9 × 3–3·5 μ, and were pale ochraceous at maturity. It was also redescribed by Massee and Crossland from specimens gathered in the Mulgrave Wood, Yorkshire, in September, 1900, see *The Naturalist* (1901) 181. C.R.

become septate: there are no septate spores in my specimens. The ascospores are hyaline so that the brownish tinge of the spores examined by Massee was probably due, as he suggests, to the age of the specimen, or the poisoning for preservation. Currey does not give the habitat of the fungus, but Massee and Phillips record it as "on the ground"; these specimens were found growing on decaying wood.

Chlorosplenium versiforme (Pers.) de Not. This Discomycete also was taken in Horner Woods during the Minehead Foray. In my specimens the discs were of a bright olive green, not a dingy green as generally described, and this was due in great part to the green colour of the spores—a point certainly overlooked in the descriptions given by Massee, Phillips and Rehm who describe the spores as hyaline and colourless*. The paraphyses which Massee and Rehm describe as slender, thickened at the tips and yellowish brown were here slender and branched, green in colour and not thickened at the tips.

Apostemidium vibrisseoides (Pk.) Boud. I gathered this fungus several times growing on rotting branches of ash lying in the water courses of Horner Woods Easter 1920. The violent shooting out of the very long ascospores from the asci was a very conspicuous feature, and as Phillips so aptly describes for *Vibrissea truncorum* "many of them remain attached by one end to the hymenium waving to and fro like floss silk glittering in the light." I watched this happening using only a pocket lens as I carried the branches on which the fungus was growing shortly after lifting them out of the water course.

Pachyella depressa (Phill.) Boud. = ? *Humaria Oocardii* Sacc. In April 1920 in the Horner Woods I found a Mollisia like Discomycete on rotten wood, lying on very damp ground, which agreed in every respect with Phillips's description of *Pachyella depressa*, and although looking like a *Mollisia* externally had microscopic characters very unlike that genus. At the mycological foray Sept. 1920 I found in several places in the same woods a Discomycete which agreed with Karsten's description of *Humaria Oocardii* var. *ligniaria*. On looking up these fungi for their position in Ramsbottom's list of British Discomycetes I found the latter species put down as probably synonymous with the former: and on examining both collections again I found them similar in every respect except that the apothecia of those taken in the spring did not show the blue colouration with iodine which was very evident when those collected in the autumn were tested with the same reagent.

Catinella olivacea (Batsch) Boud. In August 1920 Dr W. T.

* Boudier Icones IV, 283, "Spores incolores ou à peine teintées." C.R.

Elliott gathered a very good specimen of this fungus in the Woods at Marston Green (Warwicks.).

Massee in a note appended to the description of this fungus considered that the spores which are described by Batsch, Currey and others as "with an olive or bluish-green tinge would, under normal conditions, be hyaline, the bluish or purplish tinge being a stain derived from the colouring matter present in the excipulum." In making this statement he is in error for the spores of the specimen I examined which was perfectly fresh and still growing were of a greyish black tint, and contained two guttulae, thus agreeing with the original description of Batsch.

The septate paraphyses described as colourless were tinged at the apex with a yellowish colour in my specimen. They were also branched, the apices often swelling out into a clavate head, measuring 9–10 × 4–5 μ and being continuous or septate. The rhizoids attaching the apothecium to the substratum of wood were a very conspicuous feature of the fungus.

Orbilia flexuosa Crossland. During the Baslow Foray 1919, I gathered in the Highlow Wood, a Discomycete which, with the exception of colour, agrees with the description of this species.

O. flexuosa is described by Crossland as pale reddish amber the colour changing to almost black when old and dry; my specimens were conspicuously pale beetroot colour when fresh with only a slight change to a darker tint for a long while, but after two years' drying many are almost black; also the apothecia are very regular in form in contrast to the tortuous lobed forms described by Crossland; however this tortuous lobing might be due to age.

Crossland describes the paraphyses "as numerous, filiform, very slightly or not at all thickened at the apex, which is tinted orange"; the paraphyses in my specimen agree as to form, but they are colourless; some are bent at the apex and all have oily contents. This fungus appears in Ramsbottom's list of British Discomycetes as a species of doubtful position. To judge from the paraphyses my specimen is certainly a *Hyalinia*.

Mollisia caesia (Fckl.) Sacc. During the Foray in the Wyre Forest, I found a good specimen of this beautiful Discomycete growing on a chip of oak. The subiculum on which the crowded apothecia were growing was quite well-formed and abundant*. This fungus is not common: I have only taken it once before in 1916 in Windmill Naps, Tanworth-in-Arden.

When quite young the apothecia are very hairy all over, but

* These specimens should be referred to *Trichopeziza caesia* (Pers.) Boud., see Hist. et Class. des Discomycètes d'Europe, 131. C.R.

on maturity each apothecium merely has round its base a dense halo of radiating hairs apparently tethering it down to the subiculum or substratum, for the subiculum tends to disappear in older specimens.

Urceolella leuconica (Cooke) Boud. I gathered in Ockeridge Woods during the Worcester Foray 1921, a fungus which agrees with the description of this fungus in all particulars, except that very delicate hyphae radiate from the apothecia attaching them to the substratum, and also some of the delicate hyphae extend and form a delicate cobweb-like subiculum: in this feature the fungus resembles *Hyaloscypha candidata* but yet the hairs on the margin and excipulum have the attenuated form characteristic of *U. leuconica*.

Otidea violacea A. L. Sm. and Ramsb. On October 22, 1921, Miss Olive Stansfield found in Clowes Wood, Earlswood Lakes, Warwicks., a specimen of this very beautiful amethyst Discomycete growing on burnt soil. This fungus was first described by Smith and Ramsbottom (Trans. Brit. Mycol. Soc. v, p. 237, 1915) from a specimen gathered in a garden near Warwick by Mr W. B. Grove, and in the main details the Earlswood specimen agrees with this with the exception of the asci which were only about 180 μ in length compared with 360 μ the length given for the Warwick specimen.

The paraphyses were hooked at the clavate ends, while those of the Warwick specimen are given as straight, this character being commented upon as one of the features distinguishing this species from *O. leporina*; the paraphyses also were sparingly septate and many showed dichotomy near their base: as is usual among Discomycetes the colouring matter in the paraphyses give the amethyst colour to the whole fungus.

In section the hypothecium is seen to be formed of a broad band of large, septate, irregularly inflated hyphae and a narrower band consisting of more regular hyphae forming a compact layer above the excipulum which also consists of large, septate, irregularly inflated hyphae which run out into irregular parenchymatous granulations on the exterior.

The inflated cells in the hypothecium often attained great dimensions, some measuring 60 × 35 μ or even 90 × 55 μ. They very much resemble the water-storage cells found in many of the xerophytic higher plants; doubtless water-storage is their function here, these cells affording a reserve supply of water to be easily drawn upon by developing asci; but these inflated cells by changes in turgor probably play the part of motor cells, bringing about the closing or curling over movement of the walls of the apothecium during drought, and the opening out which follows on access to water again.

NOTE.

ON THE PARASITIC HABITS OF THE PLASMODIUM OF PHYSARUM VIRIDE VAR. RIGIDUM LISTER.

The following notes refer to the habitat of the plasmodium of *Physarum viride* var. *rigidum* as seen in tropical Malaya. Here this is one of the commonest and most widely distributed species, occurring especially on decaying logs of *Hevea brasiliensis*. My attention was first drawn to its possible parasitic nature by repeatedly finding the sporangia on or near the white fan-shaped pilei of *Schizophyllum commune*, the commonest of the Agaricineae found on dead Hevea; moreover the pilei on which sporangia occurred invariably presented a dried up, shrivelled, dead appearance. When the sporangia occurred on the bark of Hevea there were almost always masses of dead shrivelled Schizophyllum near by. That this appearance was not due to weather conditions was proved by the presence of other fresh growths of Schizophyllum on the same log; traces of the veins of the plasmodium could always be found on pilei bearing sporangia of the Physarum as well as on others free from sporangia in the immediate neighbourhood.

These field observations suggested an investigation into the habits of this plasmodium, and the following experiments were carried out.

Spores from freshly collected sporangia of the *Physarum* were sprinkled on damp fresh pilei of Schizophyllum gathered from a log showing no trace of Mycetozoa. In 48 hours yellow plasmodium was seen on the inoculated material kept in a damp chamber; most of the Schizophyllum was then still alive, as evidenced by the formation of new outgrowths at the bases of the stalks, but the parts of the upper surface of the pileus over which the plasmodium spread had turned a dirty brown. This change in colour and general appearance became more and more accentuated each succeeding 24 hours and by the sixth day all the Schizophyllum had been killed, the whole being then a dirty wet brown flaccid mass; from this the plasmodium was retiring and had begun to spread over the sides of the glass dish. Fresh pilei were placed in contact with the plasmodium, which in another 24 hours was spreading over the new food material. The plasmodium began to gather together into small masses preparatory to fruiting which took place the following day. The sporangia were at first yellow and remained so for some time. The final colour change occurred quickly, and almost simultaneously over the hundreds of sporangia, from a bright yellow to bronze brown. The final metallic bronzed appearance

was evident as soon as the whole was comparatively dry. During and immediately before the formation of capillitium and spores, there was no obvious evidence of extrusion of water, which is so notable a feature in the case of *Brefeldia maxima* (see Naturalist, July 1916), *Badhamia utricularis* and *Physarum nutans* in temperate regions. This may be due to the much higher temperature of South Malaya and the consequent more rapid evaporation from the outer surface of the sporangium walls.

In a further experiment a piece of Schizophyllum covered with plasmodium was removed and placed in contact with fresh *Hirneola hispida*. The rapid development of the plasmodium on the new host was extraordinary, for in 24 hours the whole surface of the Hirneola was covered with a dense network of plasmodium. The tissues of the fungus at the same time became so soft that it was impossible to lift it without breaking parts away. The plasmodium on this host assumed a lighter yellow colour and appeared more watery than on Schizophyllum.

Attempts to develop the plasmodium from spores sown on *Daldinea concentrica*, *Nummularia pithodes* and *Ustulina zonata* gave negative results, and portions of plasmodium transferred from Schizophyllum or from Hirneola to the above-named fungi all died.

A. R. SANDERSON.

REVIEW.

Lichens. By Annie Lorrain Smith, F.L.S. Demy 8vo. Cloth, pp. 464. 135 figs. 55*s*. University Press, Cambridge.

The publication of "Lichens," the second volume of the Cambridge Botanical Handbooks, removes in a very efficient manner one of the bars to the study of Lichenology, viz. that caused by the lack of a comprehensive, readable, fully illustrated text-book on the subject. There is within its pages much valuable, well arranged, recent and interesting information respecting these puzzling plants that will appeal to the botanist, who is in no way a specialist, and who would fail to be attracted by a lichen flora in spite of all the skill that might be expended upon its production. At the same time it is a book that is essential to all serious students of Lichenology by reason of the very complete and exceedingly able treatment of the subject with which it deals.

The wide scope of Miss Smith's book is plainly evident in the tabulated list of its contents, which, arranged under numerous headings and in various forms of type, immediately follows the

preface. The exhaustive bibliography of books and papers, all of which are cited in the text, also bears witness to the comprehensiveness of the volume.

It is in the preface that Miss Smith expresses an opinion that her method has somewhat overburdened the pages with citations, but it is more than probable that the student will regard this important feature of her book as a veritable mine of wealth.

In the pages of the introduction (pp. xxiii to xxviii) the author expresses a definite view, which one would expect, regarding the relation of fungus and alga as it exists in the lichen thallus. It is that "Each symbiont contributes in varying degree to the common support," but, there is clear evidence throughout the book that no attempt is made unduly to press the writer's personal opinion.

One of the most ably written chapters is that on phylogeny, a subject that is admittedly difficult to write about in clear and simple language, but Miss Smith does so without overburdening the chapter with unnecessary technicalities and in such a manner that the argument can be followed by the botanist who has no special knowledge of systematic lichenology.

The chapter devoted to Ecology gives a resumé of the present knowledge of the ecology of lichens arranged under appropriate headings. Numerous citations are given. Whether the papers referred to have been of the kind that add to the data already accumulated, or of those that theorise on what is already known, all have received recognition.

The illustrations, 315 in number (some of which are line block and others process reproduction of photographs) have not always the merit that one expects to find in a book of this class. The most favourable position for an illustration is by the printed matter that it is intended to illustrate, but this juxtaposition should not be made when the paper of the book proves unsuitable, as it certainly does, in this case, for process work. The appearance of the book would have been greatly enhanced had the photographs, on suitable paper, been inserted at the end of each chapter.

It is cause for regret that the book, which at once proves itself to be indispensable to all lichenologists, could not be produced at a much lower price than that at which it is published.

This volume together with the Monograph of British Lichens (two volumes) gives a fuller perspective of the important and laborious work that was undertaken by Miss Smith. One becomes more fully aware of the firm grip and the discriminating critical knowledge that have been exercised in the writing of this trilogy, and the writer is to be heartily congratulated on the completion of this part of her work.

R. P.

LIST OF MEMBERS.

Honorary Members.

Bresadola, L'Abbé G., Via Cr. Madruzzo 17, Trento, Italia (1921).
Patouillard, Dr N., 105, Avenue du Roule, Neuilly-sur-Seine (Seine), France (1920).
Rea, Mr Carleton, B.C.L., M.A., 6, Barbourne Terrace, Worcester (1918).
Thaxter, Professor Roland, 7, Scott Street, Cambridge, Mass., U.S.A. (1920).

Ordinary Members.

1. Aberdeen, The University Library (1916).
2. Adams, Mr J. H., Great Bedwyn, Hungerford, Wilts. (1919).
3. Adcock, Mr Archie, Upton Road, Norwich (1921).
4. Alcock, Mrs N. L., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919).
5. Alexander, Rev. Philip J., C.J., St George's College, Weybridge (1921).
6. Allen, Mr W. B., Benthall, Broseley, Salop (1902).
7. Bagchee, Mr K., Imperial College of Science, South Kensington, London, S.W. 7 (1920).
8. Baghdad, Director of Agriculture, New Street, Baghdad (1920).
9. Barnett, Miss E. C., Botany Department, Marischal College, Aberdeen (1921).
10. Barr, Rev. Robert, The Manse, Neilston, Renfrewshire (1918).
11. Barrington, Dr F. J. F., University College Hospital Medical School, University Street, London, W.C. 1 (1901).
12. Bartlett, Mr A. W., M.A., B.Sc., Dept. of Botany, Armstrong College, Newcastle-upon-Tyne (1920).
13. Batten, Dr L., Birkbeck College, Breams Buildings, Chancery Lane, London, W.C. 2 (1921).
14. Baxter, Mr W. H., 19, Ashton Terrace, Hillhead, Glasgow (1919).
15. Bayliss, Miss Jessie Sproat, D.Sc. (*see* Mrs J. S. Bayliss Elliott) (1911).
16. Beer, Mr Rudolph, B.Sc., F.L.S., Westwood, Bickley, Kent (1919).
17. Bellerby, Mr William, 8, Burton-Stone Lane, York (1917).
18. Biffen, Professor R. H., M.A., F.R.S., 136, Huntingdon Road, Cambridge (1899).

19. Bintner, Mr Jean, Ingénieur Horticole, Helmdange, Gr. Duché de Luxembourg (1919).
20. Birmingham Natural History and Philosophical Society, c/o W. E. Groves, Esq., 21, Vicarage Road, Edgbaston, Birmingham (1920).
21. Bisby, Dr G. R., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey (1921).
22. Blackman, Professor V. H., F.R.S., M.A., Imperial College of Science, South Kensington, London, S.W. 7 (1900).
23. Blackwell, Miss E. M., M.Sc., Hartley Botanical Laboratories, The University, Liverpool (1917).
24. Blagden, Mr Charles Otto, 57, Earl's Court Square, London, S.W. 5 (1910).
25. Bloom, Rev. James Harvey, 601, Bank Chambers, 329, High Holborn, London, W.C. 1 (1915).
26. Borthwick, Dr A. W., O.B.E., Royal Botanic Garden, Edinburgh (1911).
27. Bose, Professor S. R., Carmichael Medical College, Belgachia, Calcutta, India (1921).
28. Boston, The Mycological Club, c/o Miss Jessie F. Conant, 26, Prospect Street, Melrose, Mass., U.S.A. (1900).
29. Bourdot, L'Abbé H., St Priest en Murat, par Montmarault, Allier, France (1921).
30. Boyd, Mr D. A., St Clair, Caledonia Road, Saltcoats, N.B. (1906).
31. Brazier, Mr E., Brook Road, Old Swinford, Stourbridge (1921).
32. Brett, Miss M., B.Sc., Northern Polytechnic, Holloway Road, London, N. 5 (1921).
33. Brierley, Dr W. B., Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. (1919).
34. British Museum, The Trustees of, Cromwell Road, London, S.W. 7 (1914).
35. Brooks, Mr F. T., M.A., The Botany School, Cambridge (1907).
36. Brooks, Dr St John, Lister Institute, Chelsea Gardens, London, S.W. 1 (1921).
37. Brown University, East Side Station, Providence, R.I., U.S.A., Library (1920).
38. Bruxelles, Jardin Botanique de l'Etat (1911).
39. Bryce, Mr G., B.Sc., Royal Botanic Gardens, Peradeniya, Ceylon (1915).
40. Buckley, Mr W. D., 8, Victoria Street, Slough (1916).
41. Buddin, Mr Walter, M.A., Laboratory for Plant Pathology, University College, Reading (1921).
42. Buller, Professor A. H. R., D.Sc., Ph.D., F.R.C.S., University of Manitoba, Winnipeg, Canada (1911).

43. Bunting, Mr R. H., Agricultural Department, Aburi, Gold Coast Colony (1921).
44. Bunyard, Capt. G. N., 25, Bower Mount Road, Maidstone (1920).
45. Butcher, Mr R. W., Botanical Dept., The University, Leeds, and 95, Middleton Hall Road, King's Norton, Birmingham (1921).
46. Butler, Dr E. J., C.I.E., M.B., Imperial Bureau of Mycology, 17, Kew Green, Surrey (1920).
47. Cadman, Miss E. J., Imperial College of Science, South Kensington, London, S.W. 7 (1921).
48. Calcutta Museum, Professor of Botany, Biological Library, 35, Ballygunge Circular Road, Calcutta, India (1921).
49. Calder, Mr Ronald B., B.A. (Cantab.), B.Sc., East London College, Mile End Road, London, E. 1 (1920).
50. Cambridge, The Botany School (1920).
51. Carr, Professor J. W., M.A., University College, Nottingham (1896).
52. Cartwright, Mr K. St S., Rothbury, Hay, Hereford (1913).
53. Cayley, Miss D. H., John Innes Horticultural Institute, Mostyn Road, Merton, Surrey (1913).
54. Chaudhuri, Mr H., Imperial College of Science, South Kensington, London, S.W. 7 (1920).
55. Cheel, Mr Edwin, Botanic Gardens, Sydney, N.S.W., Australia (1919).
56. Cheesman, Mr W. N., J.P., The Crescent, Selby (1896).
57. Chicago, The Library, University of Illinois, U.S.A. (1914).
58. Chipp, Mr T. F., B.Sc., F.L.S., Forestry Dept., Coomassie, Gold Coast (1919).
59. Clarke, Miss H., M.Sc., 45, Beaconsfield Road, Seaforth, Liverpool (1917).
60. Clarke, Mr James Jackson, 25, Norfolk Road, London, N.W. 8 (1920).
61. Cleland, Dr J. Burton, M.D., Professor of Pathology, University of Adelaide, South Australia (1918).
62. Coimbatore, The Librarian, College of Agricultural Research, Lawley Road, P.O., Coimbatore, Madras (1918).
63. Collett, Mr R. Leslie, M.A., Lister Institute, Chelsea Gardens, London, S.W. 1 (1921).
64. Collins, Miss Florence, The School of Gardening, Clapham, near Worthing, Sussex (1920).
65. Cooper, Miss C. A., Hillside Cottage, California Road, Bushey Heath, Herts. (1911).
66. Cornell University, The Library, New York State College of Agriculture, Ithaca, N.Y. (1920).

67. Corner, Mr E. M., Woodlands Park, Great Missenden, Bucks. (1920).
68. Cotton, Mr A. D., F.L.S., Herbarium, Royal Botanic Gardens, Kew (1902).
69. Crow, Mr W. B., M.Sc., F.L.S., University College of South Wales and Monmouthshire, Cardiff (1921).
70. Curtis, Miss Kathleen M., M.A., M.Sc., D.I.C., F.L.S., Mycologist, Biological Department, Cawthron Institute of Scientific Research, Nelson, New Zealand (1917).
71. Cutting, Mr E. M., M.A., F.L.S., Botanical Dept., University College, Gower Street, London, W.C. 1 (1920).
72. Darbishire, Professor O. V., B.A., Ph.D., The University, Bristol (1913).
73. Dastur, Mr J. F., Imperial Agricultural Research Institute, Pusa, Bihar, India (1920).
74. Davis, Dr J. Jefferson, B.S., M.D., University of Wisconsin, Madison, Wisconsin, U.S.A. (1921).
75. Day, Mr E. Metcalfe, Rowan Cottage, Minchinhampton, Glos. (1921).
76. Dickinson, Mr S., Imperial College Union, South Kensington, London, S.W. 7 (1921).
77. Dowson, Mr W. J., M.A., F.L.S., R.H.S. Gardens, Wisley, Surrey (1920).
78. Drinkwater, Mr Harry, M.D., M.R.C.S., F.L.S., J.P., etc., Lister Lodge, Wrexham (1910).
79. Ealand, Mr C. A., 32, Hamlet Gardens, Ravenscourt Park, London, W. 6 (1921).
80. Edwards, Mr W. H., Curator, The Museum, Birmingham (1896).
81.* Elliott, Mrs J. S. Bayliss, Arden Grange, Tanworth in Arden, Warwickshire (1911).
81. Elliott, Dr W. T., L.D.S., R.C.S., F.Z.S., Arden Grange, Tanworth in Arden, Warwickshire (1911).
82. Else, Mr W. J., 6*a*, Britannia Square, Worcester (1921).
83. Essex Field Club, c/o Percy Thompson, Esq., F.L.S., Essex Museum of Natural History, Romford Road, Stratford, Essex, E. 15 (1919).
84. Evans, Mr William, F.R.S.E., 38, Morningside Park, Edinburgh (1911).
85. Eyre, Miss J. C., Ippelpen, Newton Abbot, Devon (1915).
86. Fenton, Mr E. W., Botanical Department, Seale-Hayne, Agricultural College, Newton Abbot, Devon (1920).
87. Finlayson, Mr Raymond A., F.L.S., The Parsonage Farm, Downton, Wilts. (1910).

88. FitzGerald, Rev. H. P., F.L.S., Lidwells, Goudhurst S.O., Kent (1896).
89. Franklin, The Hon. Mrs, Glenalla, Ray, Letterkenny, co. Donegal (1919).
90. Fraser, Miss H. C. I. (*see* Prof. Dame Helen Gwynne-Vaughan).
91. Fynes-Clinton, Rev. C. E., M.A., St James's Vicarage, Leyland, Preston (1917).
92. Gadd, Mr C. H., Royal Botanic Gardens, Peradeniya, Ceylon (1921).
93. Gardner, Capt. Frederic, c/o Lloyd's Bank, Jersey, C.I. (1898).
94. Gates, Professor R. R., B.Sc., Ph.D., King's College, Strand, London, W.C. 2 (1921).
95. Gilchrist, Miss Grace G., B.Sc., Botanical Dept., The University, Bristol (1921).
96. Goodwin, Mr D. P., Oakden, Kidderminster (1902).
97. Gould, Mr F. G., Elmhurst, Church Hill, Loughton, Essex (1918).
98. Green, Col. C. Theodore, A.M.S., M.R.C.S. (Eng.), L.R.C.P. (Lond.), F.L.S., 31, Shrewsbury Road, Birkenhead (1901).
99. Green, Mr E. Ernest, F.Z.S., F.E.S., Way's End, Camberley, Surrey (1917).
100. Grinling, Mr C. H., B.A., 71, Rectory Place, Woolwich, S.E. 18 (1913).
100.* Gwynne-Vaughan, Professor Dame Helen, D.B.E., D.Sc., LL.D., etc., 93, Bedford Court Mansions, London, W.C. 1 (1906).
101. Haas, Dr P., University College, Gower Street, London, W.C. 1 (1921).
102. Hadden, Mr Norman G., Breezy Bank, West Porlock, Somerset (1911).
103. Hansford, Mr C. J., Microbiologist, Dept. of Agriculture, Jamaica (1921).
104. Harrison, Mrs E., 11, Grosvenor Avenue, West Kirby, Cheshire (1913).
105. Harrison, Mr H. W., 11, Grosvenor Avenue, West Kirby, Cheshire (1913).
106. Harvey, Mrs Cecily D., Barwick in Elmet Rectory, near Leeds (1910).
107. Hastings, Mr Somerville, M.S., F.R.C.S., 43, Devonshire Street, Portland Place, London, W. 1 (1913).
108. Hawley, Sir H. C., The Manor House, Lytchett Matravers, Poole, Dorset (1907).
109. Hildyard, Mr F. W., 14, Lambridge, Bath (1913).

110. Hiley, Mr Wilfred E., M.A., Research Institute, School of Forestry, Oxford (1913).
111. Holmes, Mr E. Morell, F.L.S., F.R.H.S., Ruthven, Sevenoaks, Kent (1906).
112. Holt, Mr W. H., 17, Ashville Road, Birkenhead (1914).
113. Honolulu, The Library, Experiment Station, S.P.A., Box 411, Hawaii (1920).
114. Horne, Dr A. S., Botanical Dept. Imperial College of Science, South Kensington, London, W. 7 (1921).
115. Howard, Mr H. J., F.R.M.S., 6, College Road, Norwich (1918).
116. Hughes, Mr G. C., Chesterton, Bicester, Oxon. (1898).
117. Humphrey, Mr C. J., Laboratory of Forest Pathology, Old Soils Building, University of Wisconsin, Madison, Wisconsin, U.S.A. (1921).
118. Hunter, Mr C., M.Sc., Botanical Dept., The University, Bristol (1921).
119. Hurrell, Mr H. E., 25, Regent Street, Great Yarmouth (1921).
120. Illinois, The Library, University of, Urbana, Illinois, U.S.A. (1920).
121. Jack, Mr H. W., B.Sc., B.A., Economic Botanist, Dept. of Agriculture, Kuala Lumpur, Federated Malay States (1913).
122. Jewson, Miss Sybil T., B.Sc., Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. (1919).
123. Johnson, Mr J. W. Haigh, M.Sc., F.L.S., Walton, near Wakefield (1919).
124. Johnstone, Mr R. B., 134, Cambridge Drive, Glasgow (1908).
125. Jones, Mr Robert Fowler, Austral House, Woodhall Spa, Lincolnshire (1918).
126. Keef, Miss Phoebe, Mortimer Lodge, Wimbledon Park, London, S.W. 17 (1921).
127. Kelly, Dr Howard A., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921).
128. Kendall, Miss O., Pathological Laboratory, Milton Road, Harpenden, Herts. (1921).
129. Kew, The Library, Royal Botanic Gardens (1921).
129.* Kidd, Mrs Franklin, The Botany School, Cambridge (1919).
130. Knight, Mr H. H., M.A., The Lodge, All Saints Villas, Cheltenham (1914).
131. Krieger, Mr L. C. C., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921).

132. Line, Mr James, M.A., School of Agriculture, Cambridge (1921).
133. Linnean Society, Burlington House, Piccadilly, London, W. 1 (1919).
134. Lister, Mr A. B., D.I.C., B.Sc.(Lond.), Experimental and Research Station, Turner's Hill, Cheshunt, Waltham Cross, Herts. (1916).
135. Lister, Miss Gulielma, F.L.S., Leytonstone, Essex, and Highcliff, Lyme Regis (1903).
136. Lloyd, Mr C. G., The Lloyd Library and Museum, 224, West Court Street, Cincinnati, Ohio, U.S.A. (1907).
137. MacCallum, Dr B. D., M.A., D.Sc., F.L.S. Royal Botanic Gardens, Edinburgh (1921).
138. Macfie, Dr J. W. Scott, M.A., D.Sc., 21*a*, Alfred Street, Liverpool (1900).
139. Mackenzie, Miss A. D., Ministry of Agriculture, 4, Whitehall Place, London, S.W. 1 (1921).
140. Mackenzie, Mr D. Afton, Busby, N.B. (1900).
141. Main, Mr Robert, 1, Rosslyn Avenue, Low Fell, Gateshead (1918).
142. Maire, Dr René, D.Sc., Professeur à la Faculté des Sciences de l'Université, Algers (1907).
143. Maitland, Mr T. D., Government Botanist, Dept. of Agriculture, Kampala, Uganda (1916).
144. Marmont, Mr Basil P., Windsoredge House, Inchbrook, near Woodchester, Glos. (1908).
145. Marriott, Mr St John, 37, Owenite Street, Abbey Wood, London, S.E 2. (1920).
146. Marshall, Mr A., 21, Potter's Hill, Aston, Birmingham (1921).
147. Mason, Mr E. W., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey (1921).
148. Mason, Mr F. A., F.R.M.S., M.S.P.A., The Laboratory, 3, Queen's Square, Leeds (1912).
149. Mason, Mr F. R., Assistant Mycologist, Dept. of Agriculture, Kuala Lumpur, Federated Malay States (1921).
150. Matthews, Mr J. R., M.A., F.L.S., Royal Botanic Gardens, Edinburgh (1921).
151. McCutcheon, Mr William, B.A., B.Sc., Goulburn, 89, Argyle Road, Saltcoats, N.B. (1920).
152. McDougall, Professor W. B., University of Illinois, Urbana, Illinois, U.S.A. (1921).
153. Mehta, Professor K. C., The Botany School, Cambridge (1921).

154. Melbourne, The Director, Department of Agriculture, Science Branch, 605, Flinders Street, Melbourne, Australia (1921).
155. Menzies, Mr James, 117, Scott Street, Perth (1917).
156. Meulenbroff, Dr J. S., President Dutch Mycological Society, Zwolle, Holland (1921).
157. Missouri, The Botanical Garden, St Louis, Mo., U.S.A. (1902).
158. Miyabe, Dr Kingo, Professor of Botany, Hokkaido Imperial University, Sapporo, Japan (1919).
159. Montague, Mrs A. Penton, Crediton, N. Devon (1898).
160. Morris, Mr T. N., B.A., Dip. Agr. (Cantab.), St John's College, Cambridge (1919).
161. Mounce, Miss Irene, M.A., Botanical Dept., University of Manitoba, Winnipeg, Canada (1921).
162. Murray, Mr G. H., F.E.S., Papuan Government Service, Port Moresby, Papua, British New Guinea (1921).
163. Nederlandsche Mycologische Vereeniging, c/o H. A. A. van der Lek, Bennekom, Holland (1920).
164. Newcastle-upon-Tyne Literary and Philosophical Society (1902).
165. Newman, Mr Leslie F., M.A., F.L.S., Dip. Agr. (Cantab)., St Catharine's College, Cambridge (1906).
166. New York Botanical Garden, Bronx Park, New York, U.S.A. (1904).
167. Nicholson, Mr Charles, F.E.S., 35, The Avenue, Hale End, Chingford (1916).
168. Nicholson, W. E., Lewes (1913).
169. Noel, Miss E. F., F.L.S., 37, Moscow Court, London, W. 2 (1913).
170. North Carolina, University of, Chapel Hill, N.C., U.S.A. (1920).
171. Ogle, Mr B. S., Hill House, Steeple Aston, Oxon. (1904).
172. Oke, Mr Alfred William, B.A., F.G.S., F.L.S., 32, Denmark Road, Hove (1908).
173. O'Loughlin, Miss Bessie, Rocklands, Wallasey, Cheshire (1913).
174. Ontario Agricultural College Library, Guelph, Ontario, Canada (1920).
175. Osborn, Professor T. G. B., M.Sc., Professor of Botany, Adelaide University, South Australia (1910).
176. Overeem, Mr C. Van, Mycological Museum, Weesp, Holland (1920).
177. Overton, Mr H., A.C.A., Newlands, Boswell Road, Sutton Coldfield, Birmingham (1920).
178. Owen, Miss M. Nest (*see* Mrs Franklin Kidd), (1919).

179. Page, Miss W. M., B.Sc., Birkbeck College, Breams Buildings, Chancery Lane, London, W.C. 2 (1921).
180. Parke, Davis and Co., Librarian, Research Dept., Detroit, Mich., U.S.A. (1920).
181. Paul, The Very Rev. David, LL.D., D.D., 53, Fountainhall Road, Edinburgh (1899).
182. Paulson, Mr Robert, F.L.S., F.R.M.S., Glenroy, Cecil Park, Pinner, Middlesex (1918).
183. Peacock, Dr H. G., Hareston Lodge, Torquay (1896).
184. Pearson, Mr A. A., F.L.S., 59, Southwark Street, London, S.E. 1 (1911).
185. Peck, Mr A. E., Tosti, 20, Avenue Road, Scarborough (1918).
186. Peltereau, Monsieur E., Notaire honoraire, Vendôme, Loir et Cher, France (1909).
187. Perthshire Society of Natural Science, c/o James Winter (Hon. Treas.), 35, George Street, Perth (1919).
188. Petch, Mr T., B.A., B.Sc., Royal Botanic Gardens, Peradeniya, Ceylon (1911).
189. Pethybridge, Dr G. H., B.Sc., Dept. of Agriculture and Technical Instruction for Ireland, Royal College of Science, Upper Merrion Street, Dublin (1919).
190. Phillips, Mr J. F., King William's Town, South Africa, c/o Nicol, 23, Marchmont Crescent, Edinburgh (1921).
191. Phillips, Professor Reginald W., M.A., D.Sc., F.L.S., Professor of Botany, University College of North Wales, Bangor (1911).
192. Plowright, Mr C. T. P., B.A., M.B., King Street, King's Lynn (1901).
193. Potter, Rev. Professor M. C., Sc.D., M.A., F.L.S., Armstrong College, Newcastle-upon-Tyne (1896).
194. Potts, Mr George, Benthall House, Broseley, Salop (1910).
195. Priestley, Professor J. H., B.Sc., F.L.S., Botanical Dept., University of Leeds (1912).
196. Priestley, Mrs Marion E., 10, Monk Bridge Road, Headingley, Leeds (1919).
197. Pusa, Imperial Mycologist (1921).
198. Ramsbottom, Mr J., M.A., F.L.S., O.B.E., British Museum, Cromwell Road, London, S.W. 7 (1910).
199. Ramsbottom, Mr J. K., c/o Geo. Munro, Ltd., 4, Tavistock Street, Covent Garden, London, W.C. 2 (1914).
200. Rayner, Mr J. F., Swaythling, Southampton (1902).
201. Rayner, Dr M. C., Bedford College, Regent's Park, London, N.W. 1 (1921).
202. Rea, Mrs E. A., 6, Barbourne Terrace, Worcester (1896).

203. Rea, Miss M. W., Salem House, Sydenham, Belfast, Ireland (1920).
204. Rea, Miss Violet, 6, Barbourne Terrace, Worcester (1921).
205. Rhodes, Miss Mabel, Lister Institute, Chelsea Gardens, London, S.W. 1 (1921).
206. Rhymes, Mr Charles, High Bois, Chesham, Bucks. (1921).
207. Richards, Mr R. M., A.R.C.S., The Laboratory, Caledonia Estate, Province Wellesley, Straits Settlements (1915).
208. Ridler, Miss W. F. F., B.Sc., Botanical Dept., The University, Bristol (1921).
209. Roberts, Mrs A. W. Rymer, The Common, Windermere (1920).
210. Robson, Mr R., M.Sc., F.Z.S., Writtle, Chelmsford, Essex (1914).
211. Roper, Miss I. M., 4, Woodford Road, Redland, Bristol (1921).
212. Rushton, Mr W., A.R.C.S., D.I.C., St Mary's Hospital, Medical School, Paddington, London (1914).
213. St Paul, Minn., U.S.A., The Library, Dept. of Agriculture, University Farm (1920).
214. Salisbury, Dr E. J., F.L.S., University College, Gower Street, London, W.C. 1 (1921).
215. Sampson, Miss K., B.Sc., Economic Botanist, Plant Breeding Station for Wales, University College, Aberystwith (1920).
216. Sanderson, Mr A. R., F.L.S., Research Laboratory, Petaling, Federated Malay States (1921).
217. Schinz, Professor Dr Hans, Botanical Garden, Zurich (1921).
218. Scott, Mr W. Murray, Wakemills, Haslemere, Surrey (1921).
219. Searle, Mr G. Odell, B.Sc., Agric. (Lond.), Research Botanist, Linen Industry Research Association, Glenmore House, Lambeg, Lisburn, Ireland (1920).
220. Selborne Society, 42, Bloomsbury Square, London, W.C. 1 (1913).
221. Sharpe, Mr C. J., Brambleside, Manor Road, Sidcup (1905).
222. Shaw, Dr F. J. F., B.Sc., F.L.S., Imperial Agricultural Research Institute, Pusa Bihar, India (1920).
223. Small, Mr W., M.B.E., M.A., B.Sc., Mycologist, Dept. of Agriculture, Kampala, Uganda (1915).
224. Smith, Miss Annie Lorrain, F.L.S., 20, Talgarth Road, West Kensington, London, W. 14 (1899).
225. Smith, Miss K. E., 64, Coton Road, Nuneaton (1913).
226. Smith, Mr Thomas, 25, Lyme Street, Stockport (1918).

227. South London Botanical Institute, Tulse Hill, Herne Hill, S.E. 24 (1921).
228. Stationary Office, H.M., Superintendent of Publications, Book Dept., Westminster, S.W. 1 (1920).
229. Sutherland, Mr G. K., M.A., D.Sc., F.L.S., 10, Bank Parade, Preston (1914).
230. Swanton, Mr E. W., A.L.S., Brockton, Haslemere, Surrey (1899).
231. Swedish Academy of Sciences, Royal (1919).
232. Tabor, Mr Richard John, B.Sc., F.L.S., Imperial College of Science, South Kensington, London, S.W. 7 (1914).
233. Tagg, Mr H. F., F.L.S., Royal Botanic Gardens, Edinburgh (1921).
234. Tatum, Mr E. J., Salisbury (1896).
235. Taylor, Miss B. K., 98, Cheyne Walk, Chelsea, London, S.W. 3 (1910).
236. Temperley, Mr Nicholas, 4, Carlton Terrace, Low Fell, Gateshead-on-Tyne (1918).
237. Thomas, Mr H. Hamshaw, M.B.E., M.A., The Botany School, Cambridge (1910).
238. Thomson, Miss Mary R. H., c/o The Chief, Division of Botany, Box 994, Pretoria (1917).
239. Toronto, University of, Librarian, Toronto, Canada (1919).
240. Tothill, Dr Vincent, c/o Trinidad Leaseholds, Ltd., Norme l'Enfer Forest Reserve, Fyzabad, Trinidad, B.W.I. (1912).
241. United States Dept. of Agriculture (1907).
242. Vines, Professor S. H., M.A., D.Sc., F.R.S., Langstone, Exmouth, Devon (1915).
243. Wager, Dr Harold, F.R.S., F.L.S., 4, Bank View, Chapel Allerton, Leeds (1896).
244. Wakefield, Miss E. M., M.A., F.L.S., Herbarium, Royal Botanic Gardens, Kew (1911).
245. Wallis, Mr A. Westacre, Station Road, Kettering (1921).
246. West Indies, Commissioner of Agriculture for, Imperial Dept. of Agriculture, Barbados, B.W.I. (1921).
247. Wheldon, Mr H. J. (1918).
248. Whetzel, Professor H. H., Professor of Plant Pathology, New York, State College of Agriculture, Cornell University, Ithaca, N.Y., U.S.A. (1914).
249. Whitaker, Mr F. Owen, 89, Eccleston Square, London, S.W. 1 (1921).
250. Whitehead, Mr T., University College of North Wales, Bangor (1920).
251. Williams, Professor J. Lloyd, D.Sc., F.L.S., University College of North Wales, Bangor (1921).

252. Williamson, Mrs H. S., Imperial College of Science, South Kensington, London, S.W. 7 (1921).
253. Wilmott, Mr A. J., B.A., F.L.S., British Museum, Cromwell Road, South Kensington, London, S.W. 7 (1921).
254. Wilson, Mr A. E., Southey House, College Green, Bristol (1920).
255. Wilson, Dr Malcolm, D.Sc., A.R.C.S., F.L.S., Royal Botanic Garden, Edinburgh (1912).
256. Wiltshire, Mr S. P., Research Station, Long Ashton, Bristol (1920).
257. Woolhope, The Naturalists' Field Club, c/o C. S. Scobie, 2, Offa Street, Hereford (1896).
258. Worcestershire Naturalists' Field Club, c/o F. T. Spackman, Esq., F.G.S., 190, Bath Road, Worcester (1921).
259. Wormald, Dr H., South Eastern Agricultural College, Wye, Kent (1921).

RULES.

Society's name and objects.

1. The Society shall be called "The British Mycological Society," and its object shall be the study of Mycology in all its branches.

Members of Society.

2. The Society shall consist of Honorary Members, Foundation Members and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100*, but the number of Ordinary Members shall be unlimited.

Honorary Members.

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members.

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained*.

Officers.

5. The Officers of the Society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries, and Editor or Editors. They shall be elected annually at the Annual General Meeting of the Society.

Government of Society.

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

* The limit of 100 Foundation Members was reached 22nd Oct., 1903.

Period of Office.

7. The Officers and Council shall hold office as from the 1st of January following their election.

Election of Members.

8. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription.

9. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous year.

Meetings.

10. The Society shall hold one or more Meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting for the election of Officers and the transaction of other business shall coincide with the Autumn Foray.

Accounts.

11. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules.

12. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alteration to all Members.

APPENDIX.

Form of proposal for Ordinary Membership of the British Mycological Society.

.....

of .....

.....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

.....(From personal knowledge).

Certificate to be signed by the Candidate.

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

.....

INDEX.

Abies pectinata, 221
Achillea Millefolium, 81
Acremonium araucanum, 36
Acrostalagmus coccidicola, 36
Aecidium Orchidearum, 82, 83
— Prunellae, 83
Aegerita candida, 54
— Webberi, 36
Aira caespitosa, 82
Alder stick, 57
Alternaria, 173, 181
Alwisia Bombarda, 249, 253, 255
Anchusa arvensis, 82
Androsaceus Hudsonii, 3
Anthoxanthum odoratum, 83
Apostemidium vibrisseoides, 296
Arachnopeziza aurata, 293, text-fig. 1, 294
Arcyria cinerea, 13, 250, 251, 254, 255
— denudata, 11, 13, 242, 250, 254, 255
— ferruginea, 250, 254, 255
— insignis, 250, 254, 255
— nutans, 250, 254, 255
— Oerstedtii, 12, 13, 254
— virescens, 250, 254, 255
Aschersonia Aleyrodis, 29, 37, 39
— basicystis, 31
— Coffeae, 29, 32
— confluens, 29
— cubensis, 29
— Goldiana, 38
— guianensis, 30
— Henningsii, 23, 100, 157, 164
— hypocreoidea, 29
— marginata, 29, 32
— oxyspora, 30, 31
— oxystoma, 37
— placenta, 29, 31, 37
— samoensis, 29
— taitensis, 30, 31
— turbinata, 29, 31
Ascobolus magnificus, 268
Ascochyta citrullina, 173
— Lycopersici, 191
— Pisi, 174
Ascocorticium, 60
— albidum, 60
— anomalum, 60
Ascomyces anomalus, 60
Ascophanus cervarius, 1, 59
Atractium ciliatum, 115
— coccigena, 120, 123
— flammeum, 20, 21, 91, 96, 115, 117, 118, 119, 159, 163
— gelatinosum, 115
— minor, 117, 118, 119
— pallidum, 118
Atractium stilbaster, 115
— Therryanum, 115

Bacterium vermiforme, 87
Badhamia affinis, 15, 243, 253, 254
— nitens, 15
— orbiculata, 243, 251, 253, 254
— reticulata, 15
— utricularis, 246, 300
Balm of Gilead, 86
Beech log, 56
Bees, Belgian, 86
— Californian, 86
— Egyptian, 86
— Mesopotamian, 86
— Palestine, 86
— Water, 86
— Wine, 86
Belonidium deparculum, 60
Berberis arcuata, 2
Birch bark, 57
Blue-rot, 231, 232
Boletus scaber, 278, 279
Botrytis cinerea, 85
— Douglasii, 85
Bourdot, L'Abbé H., "Two New Basidiomycetes," 50
Brefeldia maxima, 300
Brooks, F. T., M.A., "An investigation of some Tomato diseases," 173
— "The inheritance of disease-resistance in plants," 71
Brooks, R. St John, M.D., D.P.H., M.A, "The National Collection of type cultures," 237
Broomella Ichnaspidis, 27, 94, 95, 153, 163
— major, 153, 163
Brunella vulgaris, 83
Buller, A. H. R., D.Sc., Ph.D., F.R.C.S., "On the audibility of the 'puffing' in the larger Discomycetes," 4
— "Slugs as mycophagists," 270
— "The basidial and oidial fruit-bodies of *Dacryomyces deliquescens*," 226
— "Upon the ocellus function of the subsporangial swelling of *Pilobolus*," 61
Butler, E. J., C.I.E., D.Sc., M.B., F.L.S., "The Imperial bureau of mycology," 168

Calonectria coccidophaga, 96, 141, 153, 161, 165, Pl. IV, figs. 3–4, Pl. V, fig. 7
Catinella olivacea, 296

Cephalosporium, 283
— Lecanii, 36, 37, 39
Ceratiomyxa flexuosa, 243, 253, 254
— fruticulosa, 243, 253, 254
Ceratostoma piliferum, 231
Ceratostomella cana, 231
— coerulea, 231
— Piceae, 231, 232, 233, 235, 236, Pl. VIII, figs. 2–7
— pilifera, 231, 232
— Pini, 231, 232, 233
Chionaspis salicis, 1
Chlorella, 45
— miniata, 45
— vulgaris, 43, 44
Chlorosplenium versiforme, 1, 296
Cienkowskia reticulata, 247, 253, 254
Cladonia digitata, Pl. I, fig. 6
Cladosporium, 233
— fumago, 217, 218
Clathrus cancellatus, 3
Clavaria luteoalba, 1
— stricta, 2
Cnicus arvensis, 59
Coccidophthora variabilis, 24, 95
Colletotrichum phomoides, 173, 194, 196
Collett, R. Leslie, "Longevity of spores of a fungus in a museum specimen," 217
Colloderma oculatum, 11, 15
Comatricha elegans, 15
— irregularis, 248, 253, 255
— laxa, 247, 253, 255
— longa, 248, 253, 255
— pulchella, 247, 250, 253, 255
— tenerrima, 14
— typhoides, 248, 253, 255
Coniophorella olivacea, 50
Coprinus comatus, 211, 215
— cordisporus, 210, 211, 215
— curtus, 210, 211, 215, Pl. VI, fig. 13
— ephemeroides, 213
— ephemerus, 210, 213, 215, Pl. VI, fig. 12
— fimetarius, 198, 207, 213, 256, 258, 261, 268
— flocculosus, 1
— lagopus, 205, 213, 215, 216, Pl. VI, figs. 5–8, Pl. VII, fig. 2, 256, 257, 258, 259, 260, 261, 262, 263, 264, 266, 267, 268, 269
— niveus, 209, 213, 214, 215, 216, Pl. VI, figs. 10–11, 256, 257, 258, 259, 265, 266, 267, 268, 269
— picaceus, 1
— stellatus, 201, 210, 211, 215
— stercorarius, 207, 213, 215, Pl. VI, fig. 9, 256, 257, 260, 266, 269
— sterquilinus, 203, 213, 214, 215, Pl. VI, figs. 1–4, Pl. VII, fig. 1, 256, 257, 259, 260, 266, 269
Corallomyces, 113, 114, 115
— aurantiicola, 158
— elegans, 113
— flammea, 114
— repens, 114
Cordyceps, 27
— clavulata, 28
— coccigena, 28
— dipterigena, 28
— pistillariaeformis, 27, 28, 40
Corticium filicinum, 51
— lividum, 50
— Pearsonii, 51, and text-fig. 1, 52
— rubropallens, 50
— sphaerosporum, 56
— submutabile, 56
Cortinarius caninus, 278, 279, 280, 281
Council, 1
Craterium minutum, 14, 247, 253, 255
Creonectria, 133
Cribraria aurantiaca, 13
— dictydioides, 253, 255
— intricata, 246, 248, 253, 255
— microcarpa, 253, 255
— notabilis, 12
— pyriformis, 12, 13
— splendens, 255
— violacea, 248, 253, 255
Cronartium ribicola, 83
Cyphella alboviolascens, 1
Cystococcus, 44
Cytotriplospora, 47
— Pini, 47 and text-fig. 48

Dacryomyces deliquescens, 226, 228, 230
— stillatus, 226, 229, 230
Daisies, Michaelmas, 283
Dasyscypha calyciformis, 79
— crystallina, 59
— diplocarpa, 295, text-fig. 2, 295
— subtilissima, 79
Diachaea cerifera, 15
— leucopoda, 247, 253, 255
Dialonectria coccicola, 161
Dianema corticatum, 15
Dictydiaethalium plumbeum, 249, 253, 255
Dictydium cancellatum, 11, 13, 248, 253, 255
Diderma arboreum, 247, 253, 255
— effusum, 11, 247, 253, 255
— hemisphericum, 247, 253, 255
— ochraceum, 14
Didymium Clavus, 14, 247, 253, 255
— dubium, 10
— leoninum, 253, 255
— nigripes, 247, 253, 255
Diplodina citrullina, 175, 189
— destructiva, 175, 196
— Lycopersici, 191, 192, 196
Discofusarium, 25, 143, 164

Discofusarium Mytilaspidis, Pl. V, fig. 13
— tasmaniense, 25, 143, 161, 165, Pl. IV, figs. 1–2, Pl. V, fig. 13
Disease-resistance in plants, Inheritance of, 71
Dowson, W. J., M.A., F.L.S., "On the symptoms of wilting of Michaelmas Daisies produced by a toxin secreted by a Cephalosporium," 283
Dung, red deer, 1, 59
Duplicaria Empetri, 85

Elliott, J. S. Bayliss, D.Sc., "Studies in Discomycetes III," 293
— "Three Fungi Imperfecti," 47
Empetrum nigrum, 84
Empusa Lecanii, 34
Endoconidiophora coerulescens, 231
Endothia Passeriniana, 121
Enerthenema papillatum, 15
Enteridium olivaceum, 12, 13
Enterographa crassa, 16
Entomogenous fungi, Studies in, 89
Eremascus albus, 293, 294
Erionema aureum, 245, 253, 254
Erysiphe graminis, 76
Evernia prunastri, 4, 41, Pl. I, figs. 1–5
Exidia Thuretiana, 55

Femsjonia luteoalba, 2
Fomes robustus, 221
Forays—Haslemere, 2, 221
— Minehead, 1
— Worcester, 2
Fuligo cinerea, 245, 253, 254
— muscorum, 10, 15
— septica, 11, 245, 253, 254
Fumago vagans, 218
Fungi, complete list of, gathered during the forays, 4
— New British Hymenomycetes, 55
— New or rare British Discomycetae, 58
— Notes on new or rare British, 79
— Studies in Discomycetes, III, 293
— Three Fungi Imperfecti, 47
— Two new Basidiomycetes, 50
Fusarium, 25, 99
— Aleyrodes, 96, 156, 164, Pl. V, fig. 12
— Aspidioti, 35, 95, 154, 155, 164, Pl. V, fig. 23
— coccidicola, 35, 94, 95, 106
— coccinellum, 22, 96, 123, 159, 163
— epicoccum, 35, 40, 93, 95, 153, 154, 155, 156, 164, Pl. V, fig. 19
Fusicoccum acuum, 49
— bacillare, 49
— dolosa, 49
Fusisporium coccinellum, 123, 159, 163

Ganoderma applanatum, 3, 221
— australe, 3
— laccatum, 3
— lucidum, 3
— resinaceum, 3
— vegetum, 3
Geaster fimbriatus, 2
Gentiana acaulis, 81
— asclepiadea, 81
— verna, 81
Geotrichum coccophilum, 36
Gloeosporium acerinum, 49
Grandinia tabacina, 57
Graphium penicillioides, 234, 235, 236
Grass, dead stems of, 59

Haddon, Norman G., "Mycetozoa at Porlock in October, 1920," 13
Hapalosphaeria deformans, 84
Haslemere, 2, 221
Helotium lechithinum, 58
— moniliferum, 4
Hemitrichia clavata, 11, 242, 249, 254, 255
— minor, 15
— Serpula, 250, 254, 255
— Vesparium, 11, 249, 254, 255
Heterochaete, 52
— dubia, 52
Heterochaetella, 52, 53
— crystallina, text-fig. 2, 52, 53
— dubia, 52
Hirneola Auricula-Judae, 2
Humaria lechithina, 58
— Oocardii, 296,
Hyalinia, 297
— turgidella, 59
Hyalopus Yvonis, 36
Hyaloscypha candidata, 298
Hygrophorus lacmus, 1
— subradiatus, 1
Hypochnus elaeodes, 57
— granulosus, 3, 57
— lavandulaceus, 57
— roseogriseus, 3, 57
— sphaerosporus, 56
Hypocrella, 30
— cavernosa, 31
— Gartneriana, 32
— phyllogena, 31
— Raciborskii, 31
— scutata, 32
— turbinata, 31
Hypoderma brachysporum, 81
— pinicola, 79
Hypodermella sulcigena, 80, 81

Johnstone, R. B., "Audibility of the spore discharge in *Otidea leporina*," 86
Juniperus communis, 53

Knight, H. H., M.A., "Lichens of Haslemere District," 225
— Review of "A Handbook of the British Lichens by A. Lorrain Smith," 219
— "The Lichens of Minehead District," 16
Kuehneola albida, 4

Lachnum crystallinum, 59
Lamproderma arcyrionema, 12, 248, 253, 255
— columbinum, 14
— violaceum, 14
Larix leptolepis, 85
Lasiobolus macrotrichus, 1
Lecaniascus polymorphus, 36
Lepidoderma tigrinum, 14
Lepiota excoriata, 2
— Friesii, 4
— haematosperma, 4
— nympharum, 4
Leptogium Burgessii, 16
Licea flexuosa, 11, 13, 15
Lichens, by A. Lorrain Smith, F.L.S., 300
— A Handbook of the British, 219
— of Haslemere district, 225
— of Minehead district, 16
Lisea Parlatoriae, 27, 94, 95, 140, 157
Lister, Gulielma, F.L.S., 1
— "Mycetozoa found during the Minehead foray," 10
Lobaria pulmonaria, 16
Lycogala epidendrum, 249, 254, 255

MacCallum, B.D., M.A., D.Sc., F.L.S., "Some wood-staining fungi," 231
Macrosporium, 4
— tomato, 193, 194
Margarita metallica, 251, 254, 255
Marriott, St John, "On the discharge of the peridiolum in Sphaerobolus," 4
Medlar, 287
Medusomyces Givesii, 3
Meetings, 220, 324
Melampsorella Caryophyllacearum, 83
Melampyrum pratense, 83
Melanospora parasitica, 27
Melasmia Empetri, 84
Members, 302
— honorary, 2
Merulius tremellosus, 1
Mespilus germanica, 287
Microcera, 18, 22, 89, 96
— aurantiicola, 22, 110, 112, 136, 158, 163
— coccidophthora, 112, 160, 163
— coccophila, 19, 20, 21, 22, 89, 90, 91, 93, 95, 99, 100, 109, 110, 111, 112, 113, 115, 117, 118, 120, 122, 123, 124, 128, 129, 135, 152, 159, 163
Microcera curta, 25, 35, 95, 99, 155, 164
— Fujikuroi, 23, 95, 99, 100, 101, 105, 157, 164
— Henningsii, 157, 164
— Merrillii, 23, 95, 99, 100, 106, 157, 164
— Mytilaspis, 24, 94, 95, 100, 141, 142, 143, 161, 165
— Parlatoriae, 25, 35, 94, 95, 99, 154, 164
— pluriseptata, 21, 96, 100, 113, 123, 159, 163
— rectispora, 25, 92, 93, 95, 100, 152, 165
— tasmaniensis, 24, 94, 95, 100, 141, 142, 143, 161, 165
— Tonduzii, 25, 35, 95, 99, 155, 164
Milesina Blechni, 3
— Dieteliana, 3
Minehead, 1
Molinia caerulea, 82, 83
Mollisia caesia, 297
Mounce, Irene, M.A., "Homothallism and heterothallism in the genus Coprinus," 256
— "Homothallism and the production of fruit-bodies by monosporus mycelia in the genus Coprinus," 198
Mucronella aggregata, 58
Mycetozoa, at Porlock in October, 1920, 13
— List of, 10
— Notes on Malayan, 239
Mycorhiza in orchids, 3
Mycosphaerella citrullina, 173, 174, 175, 188, 189, 190, 196
Myriangium, 33
— Acaciae, 33
— Duriaei, 1, 33, 123

Naemaspora Strobi, 49
Nectria aglaothele, 19, 20, 92, 95, 97, 110, 111, 120, 159
— aurantiicola, 19, 21, 92, 94, 95, 97, 99, 110, 111, 112, 113, 114, 124, 127, 130, 131, 152, 158
— barbata, 25, 96, 140, 158, Pl. III, fig. 14, Pl. V, figs. 4–6
— coccicida, 122
— coccicola, 143, 161
— coccidophthora, 19, 94, 95, 97, 110, 111, 113, 129, 130, 131, 132
— coccogena, 23, 24, 92, 95, 135, 157, Pl. V, fig. 18
— coccophila, 24, 94, 95, 136, 157
— coccorum, 23, 24, 92, 95, 134, 135, 157
— Colletiae, 110

Nectria diploa, 24, 96, 97, 100, 133, 134, 135, 137, 157, 164, Pl. III, fig. 13, Pl. V, fig. 22
— episphaeria, 91, 109, 128, 129
— guaranitica, 133
— haematococca, 124
— laeticolor, 20, 96, 97, 112, 113, 120, 133, 159
— longispora, 157
— minuta, 133
— muscivora, 20, 110, 111, 116, 118, 119, 120, 121, 159
— myrticola, 96, 135, 157
— oidioides, 96, 135, 157
— Passeriniana, 20, 22, 96, 121, 159
— Ralfsii, 122
— sanguinea, 121
— subcoccinea, 20, 96, 97, 110, 111, 121, 159
— Tuberculariae, 25, 96, 138, 140, 157, 163, Pl. IV, fig. 8, Pl. V, fig. 9
— variabilis, 24, 95, 137, 157
— viticola, 121
Nephromium lusitanicum, 16
Niptera Taxi, 60

Oak stump, 56
Oidium alphitoides, 4
Ophionectria, 26, 144
— Aurantii, 151
— coccicola, 25, 26, 92, 93, 94, 95, 139, 143, 144, 145, 146, 149, 150, 151, 161
— tetraspora, 26, 95, 144, 150, 151, 152, 162
— trichospora, 144
Orbilia flexuosa, 297
Orchis latifolia, 82
Otidea leporina, 86
— violacea, 298

Pachyella depressa, 3, 296
Paepalopsis deformans, 84
Pannaria, 16
Parmeliella, 16
Patouillardiella Aleyrodis, 96, 154, 163
Paulson, R., F.L.S., Review of "Lichens," by A. Lorrain Smith, 300
— "The sporulation of gonidia in the thallus of *Evernia prunastri*," 4, 41
Paxillus panuoides, 3
Pearson, A. A., F.L.S., "New British Hymenomycetes," 55
Penicillium coccophilum, 36
— crustaceum, 294
Peniophora accedens, 51
— aegerita, 54
— argillacea, 53
Peniophora chordalis, 53
— cineracea, 52
— clavigera, 53
— detritica, 53
— glebulosa, 51, 52
— laevis, 57
— sphaerospora, 57
— subalutacea, 52
— sublaevis, 50
Perichaena chrysosperma, 251, 254, 255
— depressa, 11, 251, 254, 255
— vermicularis, 242, 251, 254, 255
Pestalozzina Rollandi, 48
Petch, T., B.A., B.Sc., 1
— "Fungi parasitic on scale insects," 2, 18
— "Studies in entomogenous fungi," 89
Peziza caesia, 297
— diplocarpa, 295
— lechithina, 58
— turgidella, 59
— vesiculosa, 275
Pezizella turgidella, 59
Phaeographis dendritica, 16
Phallus imperialis, 3
— impudicus, 275, 276, 277, 278, 283
Philonectria variabilis, 95
Phoma abietina, 79
— alternariaceum, 192, 193, 196
— destructiva, 173, 190, 196
— Lycopersici, 175, 189, 190, 191, 196
Phomopsis Tulasnei, 49
Physarella oblonga, 246, 253, 254
Physarum aurantium, 244, 253, 254
— auriscalpium, 240, 244, 253, 254
— bitectum, 11
— columbinum, 244, 253, 254
— compactum, 244
— compressum, 254
— fulvum, 253, 254
— incanum, 244, 253, 254
— lateritium, 245, 253, 254
— leucopus, 10
— melleum, 243, 253, 254
— nucleatum, 240, 245, 253, 254
— nutans, 242, 244, 300
— psittacinum, 253, 254
— pusillum, 245, 253, 254
— reniforme, 245, 253, 254
— rigidum, 244, 246, 253, 254, 299
— virescens, 245, 253, 254
— viride, 244, 253, 254, 299
Picea excelsa, 79, 233
Pilobolus, 61
Pinus Cembra, 83
— Lambertiana, 83
— monticola, 83
— nana, 81
— ponderosa, 231, 232

Pinus Strobus, 81
— sylvestris, 47, 49, 51, 52, 53, 57, 58, 61, 79, 232, 233
Pleurococcus, 43
Pleurotus corticatus, 4
Podonectria, 27, 143, 146, 161
— Aurantii, 27, 146, 149, 151, 152, 162, 165, Pl. IV, fig. 10, Pl. V, fig. 14
— coccicola, 27, 146, 153, 161, 165, Pl. IV. fig. 9, Pl. V, figs. 1–3, 15
— coccophila, 146
— echinata, 27, 96, 146, 151, 162, 165, Pl. IV, fig. 7
Podosphaera myrtillina, 1
Polygonum viviparum, 82
Poria sanguinolenta, 2
Presidents
— Petch, T., B.A., B.Sc., 2, 18
— Rea, Carleton, B.C.L., M.A., 1
Proceedings, 220, 302
Protococcus, 44, 46
— viridis, 43, 45
Pseudomicrocera, 23, 24, 97, 99, 100, 164
— Henningsii, 23, 24, 100, 135, 136, 137, 157, 164, Pl. III, figs. 9–12, Pl. V, figs. 8, 17, 20, 21
— longispora, 100, 107
Pseudotsuga Douglasii, 85
Puccinia Absinthii, 3
— Anthoxanthi, 83
— Brunellarum-Moliniae, 83
— dispersa, 82
— Epilobii, 221
— Gentianae, 81
— glumarum, 72
— Millefolii, 81
— Moliniae, 3, 82, 83
— nemoralis, 83
— Pazschkei, 81
— secalina, 82
— septentrionalis, 82
— Tritici, 72
— triticina, 73
Pustularia catinus, 4
— lecithina, 58
Puttemansia, 26, 94, 145
— Aurantii, 26, 94, 95, 146, 149, 162
— coccicola, 161
— lanosa, 145, 146

Ramsbottom, J., M.A., F.L.S., O.B.E., 1
— "Californian Bees," 86
— "Diamond spot," 4
— "Ginger Beer Plant," 3, 86
— "Medusomyces Givesii," 3
— "Mycorhiza in Orchids," 3
Rea, Carleton, B.C.L., M.A., 1
— "Error in Boudier's micrometric measurements," 218
— "New or rare British Discomycetae," 58
— "The genus Ganoderma," 3
Reticularia Lycoperdon, 249, 254, 255
Rhytisma Empetri, 85
Rubus fruticosus, 84
Rules, 314
Russula heterophylla, 278, 283
— incarnata, 2
— nigricans, 278, 279, 280, 281, 283

Saccharomyces pyriformis, 87
Sanderson, A. R., F.L.S., "Notes on Malayan mycetozoa," 239
— "On the parasitic habits of the plasmodium of *Physarum viride* var. *rigidum* Lister," 299
Saxifraga Aizoon, 81
— Cotyledon, 81
— cultrata, 81
— Hostii, 81
— longifolia, 81
— rhaetica, 81
Schizophyllum commune, 199, 200, 214, 256, 258, 264, 265, 268, 269
Scleroderris gigaspora, 26, 95, 149, 161
Sclerotinia Ariae, 287
— cinerea, 289
— fructigena, 289
— laxa, 289
— Mespili, 287, 291, 292, 293
Scoleconectria, 26, 144, 145
— coccicola, 161
Searle, G. O., B.Sc., "An investigation of some tomato diseases," 173
Sebacina, 53, 55
— ambigua, 55
— caesia, 55
— cristata, 55
— fugacissima, 56
— incrustans, 55
— sebaceum, 55
Secretary, General, 1
Septobasidium, 34
— pedicellatum, 34
— rameale, 34
Septoria thecicola, 2
Slugs as mycophagists, 270
Sphaeria clavulata, 28
— muscivora, 117
— pseudovillosa, 113
Sphaerobolus stellatus, 4
Sphaeronema Lycopersici, 191
Sphaerostilbe, 19, 91, 109, 114, 115
— aurantiaca, 114

Sphaerostilbe aurantiicola, 21, 22, 35, 40, 111, 112, 114, 116, 123, 124, 128, 129, 131, 136, 137, 154, 156, 158, 163, Pl. III, figs. 1–5, Pl. V, figs. 10–11, 16
— cinnabarina, 114
— coccidophthora, 21, 22, 112, 113, 114, 120, 129, 136, 160, 163, Pl. III, fig. 6
— coccophila, 19, 21, 93, 95, 109, 110, 111, 112, 118, 121, 123, 127, 128, 129, 136, 158, 159
— flammea, 19, 20, 21, 22, 35, 40, 96, 97, 99, 111, 112, 113, 114, 115, 118, 119, 120, 121, 122, 123, 124, 136, 159, 163, Pl. III, figs. 7–8
— gracilipes, 114
— repens, 113, 114
— variabilis, 114
Spiraea ulmaria, 60
Spores, audibility of the discharge in *Otidea leporina*, 86
— "audibility of the 'puffing' in the larger Discomycetes," 4
— error in Boudier's measurements, 218
— longevity of, 217
Sporotrichum globuliferum, 36
— Lecanii, 36
Stellaria Holostea, 83
Stemonitis ferruginea, 15, 247, 253, 255
— flaccida, 11
— fusca, 247, 253, 255
— herbatica, 15
— hyperopta, 12, 13
— splendens, 11, 247, 253, 255
Stemphylium, 4
Stereum Karstenii, 50
— purpureum, 50, 214
Sticta, 16
Stilbum, 18
— coccophilum, 36
— flammeum, 20, 91, 115, 118, 159
Synechoblastus nigrescens, 16

Taxus baccata, 60
Tetracium, 25, 94, 100, 145
— Aurantii, 26, 94, 95, 145, 146, 162, 165
— coccicola, 145
— coccicolum, 161, 165
— echinatum, 162, 165
— rectisporum, 152, 165
Thalictrum alpinum, 82
Thecospora Vacciniorum, 1
Thelotrema lepadinum, 16
Tomato diseases, 173
Torrubiella, 27
— brunnea, 27
— Lecanii, 27
— luteorostrata, 27
— rubra, 27
Treasurer, 2
Tremella epigaea, 55
Trichamphora, pezizoides, 246, 253, 254
Trichia affinis, 249, 254, 255
— Botrytis, 11, 249
— cerifera, 11
— decipiens, 249
— favoginea, 12
— floriformis, 11
— persimilis, 249, 254, 255
— varia, 242, 249
Tricholoma columbetta, 2
Trichopeziza caesia, 297
Tubercularia ciliata, 115
— coccicola, 25, 95, 139, 158, 163, Pl. IV, figs. 5–6
Tubifera ferruginosa, 249, 253, 255
— stipitata, 249, 253, 255

Urceolella deparcula, 60
— leuconica, 298
Uredo Scolopendri, 3
Urocystis Cepulae, 65, Pl. II, figs. 1–18

Verticillium heterocladum, 36
Vice-Presidents
— Lister, Gulielma, F.L.S., 1
— Petch, T., B.A., B.Sc., 1
Volutella ciliata, 115

Whitehead, T., A.R.C.S., "On the life history and morphology of *Urocystis Cepulae*," 65
Wilson, Malcolm, D.Sc., F.L.S., F.R.S.E., "Notes on new or rare British fungi," 79
Wood, 56, 58
Wormald, H., "Observations on a Discomycete found on Medlar fruits," 287

Xylaria clavulata, 28

Zygodesmus granulosus, 57

ERRATA.

p. 104, line 38, *for* Pl. IV *read* Pl. III.

p. 117, line 27 *for* 80 *read* 86.

p. 118, line 7, *for* Moquolia *read* Magnolia.

p. 154. The section on Patouillardiella, lines 21–34, should precede Fusarium, p. 153, line 35, p. 154, *et seq.*, refer to Fusarium.

PROCEEDINGS, 1921.

MEETING. UNIVERSITY COLLEGE, LONDON. *November 19th.*

Dr G. R. Bisby. The use of fungicides on potatoes in North America.

Dr W. Brown. The growth of fungi in culture.

Mr W. N. Edwards. An Eocene Microthyriaceous fungus from Mull, Scotland.

Professor Dame H. C. I. Gwynne-Vaughan. The grouping of the simpler Ascomycetes.

Dr A. S. Horne. Fungi from a diseased Hevea trunk.

PRINTED IN ENGLAND BY J. B. PEACE, M.A. AT THE CAMBRIDGE UNIVERSITY PRESS

The whole of the first part of the British Mycological Society's Transactions (Season 1896–1897) has now been sold.

The other parts may be purchased at the following prices:—

Vol. I.		
Season 1897-1898	at . .	5/6
1898-1899	at . .	5/6
1899-1900	at . .	7/6
1900-1901	at . .	11/6
Vol. II.		
1902	at . .	11/6
1903	at . .	11/6
1904	at . .	15/-
1905	at . .	15/-
1906	at . .	15/-
Vol. III.		
1907	at . .	15/-
1908	at . .	16/-
1909	at . .	16/-
1910	at . .	16/-
1911	at . .	16/-
Vol. IV.		
1912	at . .	16/-
1913	at . .	16/-
Vol. V.		
1914	at . .	16/-
1915	at . .	16/-
1916	at . .	16/-
Vol. VI.		
1917	at . .	16/-
1918	at . .	16/-
1919	Pt III at .	8/-
1919	Pt IV at .	10/6
Vol. VII.		
1920	Pts I & II at	12/6
1920	Pt III at .	12/6

All applications respecting past Transactions should be made to the Treasurer.

CONTENTS

	PAGE
Haslemere, Spring Foray	221
Lichens of Haslemere District. By H. H. Knight, M.A..	225
The Basidial and Oidial Fruit-Bodies of Dacryomyces Deliquescens. By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.	226
Some Wood-Staining Fungi. By B. D. MacCallum, M.A., D.Sc., F.L.S.	231
The National Collection of Type Cultures. By R. St John Brooks, M.D., D.P.H., M.A.	237
Notes on Malayan Mycetozoa. By A. R. Sanderson, F.L.S.	239
Homothallism and Heterothallism in the Genus Coprinus. By Irene Mounce, M.A. (British Columbia)	256
Slugs as Mycophagists. By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.	270
On the Symptoms of Wilting of Michaelmas Daisies produced by a Toxin secreted by a Cephalosporium. By W. J. Dowson, M.A., F.L.S.	283
Observations on a Discomycete found on Medlar Fruits. By H. Wormald, D.Sc.	287
Studies in Discomycetes. III. By Jessie S. Bayliss Elliott, D.Sc. (Birm.), B.Sc. (Lond.)	293
Note. The Parasitic Habits of the Plasmodium of Physarum viride var. rigidum Lister. A. R. Sanderson	299
Review	300
List of Members	302
Rules	314
Index	317
Errata	324
Proceedings	324

PRINTED IN ENGLAND BY J. B. PEACE, M.A. AT THE CAMBRIDGE UNIVERSITY PRESS

4 95
1

New York Botanical Garden Library
3 5185 00280 1643